LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

LEVEL

0

INVENTORY

DTIC ACCESSION NUMBER

Remedial Action Plan for Expanded . . .

DOCUMENT IDENTIFICATION

Apr 96

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

DISTRIBUTION STATEMENT

H A N D L E W I T H C A R E

ACCESSION FOR
NTIS GRA&I ☑
DTIC TRAC ☐
UNANNOUNCED ☐
JUSTIFICATION

BY
DISTRIBUTION/
AVAILABILITY CODES

DISTRIBUTION	AVAILABILITY AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

DATE ACCESSIONED

DATE RETURNED

20001215 108

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

DTIC FORM JUN 90 70A

DOCUMENT PROCESSING SHEET

PREVIOUS EDITIONS MAY BE USED UNTIL STOCK IS EXHAUSTED.

LOAN DOCUMENT

FINAL

Remedial Action Plan for Expanded Bioventing System Buildings 2034/2035

Fairchild Air Force Base
Washington

Prepared For

Air Force Center for Environmental Excellence
Technology Transfer Division
Brooks Air Force Base
San Antonio, Texas

and

92 CES/CEV
Fairchild Air Force Base
Washington

April 1996

PARSONS
ENGINEERING SCIENCE, INC.

1700 Broadway, Suite 900 • Denver, Colorado 80290

AQM01-03-0553

DEFENSE TECHNICAL INFORMATION CENTER
REQUEST FOR SCIENTIFIC AND TECHNICAL REPORTS

Title AFCEE Collection

1. Report Availability *(Please check one box)*

☒ This report is available. *Complete sections 2a - 2f.*

☐ This report is not available. *Complete section 3.*

2a. Number of Copies Forwarded 1 each

2b. Forwarding Date July/2000

2c. Distribution Statement *(Please check ONE box)*

DoD Directive 5230.24, "Distribution Statements on Technical Documents," 18 Mar 87, contains seven distribution statements, as described briefly below. Technical documents MUST be assigned a distribution statement.

☒ DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

☐ DISTRIBUTION STATEMENT B: Distribution authorized to U.S. Government Agencies only.

☐ DISTRIBUTION STATEMENT C: Distribution authorized to U.S. Government Agencies and their contractors.

☐ DISTRIBUTION STATEMENT D: Distribution authorized to U.S. Department of Defense (DoD) and U.S DoD contractors only.

☐ DISTRIBUTION STATEMENT E: Distribution authorized to U.S. Department of Defense (DoD) components only.

☐ DISTRIBUTION STATEMENT F: Further dissemination only as directed by the controlling DoD office indicated below or by higher authority.

☐ DISTRIBUTION STATEMENT X: Distribution authorized to U.S. Government agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoD Directive 5230.25, Withholding of Unclassified Technical Data from Public Disclosure, 6 Nov 84.

2d. Reason For the Above Distribution Statement *(in accordance with DoD Directive 5230.24)*

2e. Controlling Office

HQ AFCEE

2f. Date of Distribution Statement Determination

15 Nov 2000

3. This report is NOT forwarded for the following reasons. *(Please check appropriate box)*

☐ It was previously forwarded to DTIC on .... *(date)* and the AD number is ....

☐ It will be published at a later date. Enter approximate date if known. ....

☐ In accordance with the provisions of DoD Directive 3200.12, the requested document is not supplied because:

Print or Type Name: Laura Peña

Signature: Laura Peña

Telephone: 210-536-1431

(For DTIC Use Only)

AQ Number M01-03-0553

FINAL REMEDIAL ACTION PLAN FOR EXPANDED BIOVENTING SYSTEM AT BUILDINGS 2034/2035 FAIRCHILD AIR FORCE BASE, WASHINGTON

Prepared for

Air Force Center For Environmental Excellence
Brooks Air Force Base, Texas

And

92 CES/CEVR
Fairchild Air Force Base, Washington

April 1996

Prepared by:

Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290

022/726876/374.WW6

CONTENTS

TABLES

FIGURES

SECTION 1

INTRODUCTION

This remedial action plan (RAP) presents the scope for an expanded bioventing system for *in situ* treatment of fuel-contaminated soils in the vicinity of Buildings 2034 and 2035 at Fairchild Air Force Base (AFB), Washington. The proposed expanded system activities will be performed by Parsons Engineering Science, Inc. (Parsons ES) for the Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division (ERT) under contract F41624-92-D-8036, 0017. The primary objectives of the bioventing system upgrade are to:

- Deliver oxygen to contaminated subsurface soil throughout affected portions of the site;
- Provide additional characterization data for closure;
- Continue aerobic *in situ* remediation of fuel-contaminated soils by injection of atmospheric air into soil; and
- Sustain aerobic *in situ* biodegradation until hydrocarbon-contaminated soils within the unsaturated zone are remediated to below regulatory approved standards.

Extended bioventing pilot tests were performed at Buildings 2034 and 2035 from March 1994 through August 1995 to determine if *in situ* bioventing would be a feasible cleanup technology for the fuel-contaminated soils within the unsaturated zone. A radius of oxygen influence of at least 33 feet was observed at each site. Further detail on the pilot test procedure and results can be found in the Interim Pilot Test Results Report (Engineering-Science, Inc. [ES], 1994).

Following the extended pilot test, soil and soil gas data confirmed significant contaminant removal in the pilot test areas. Based on laboratory results from soil and soil gas samples, significant reductions in total volatile hydrocarbons (TVH), benzene, toluene, ethylbenzene, and xylenes (BTEX) were observed in soil gas, and significant reductions in total recoverable petroleum hydrocarbon (TRPH) and BTEX concentrations were observed in soil over the extended pilot test period. In addition, the extended pilot test demonstrated that significant oxygen utilization and biodegradation are continuing at the pilot test locations, and that continued bioventing will sustain the biodegradation. Further detail on the pilot test results is presented in Section 3. The success of bioventing at these sites supports the recommendation of an expanded (full-scale) bioventing system as the most economical approach of remediating the remaining hydrocarbon-contaminated soils in the vicinity of Buildings 2034 and 2035.

This RAP addresses soil contamination potentially associated with fuel releases from both Buildings 2034 and 2035. Site investigation data collected to date indicate that the majority of soil contamination in the vicinity of Buildings 2034 and 2035 is "smear zone" contamination. Smear zone contamination results when dissolved or free-phase petroleum hydrocarbons sorb to soils near the groundwater surface. Smearing occurs as a result of fluctuations in the groundwater surface elevation. It appears that a significant release of petroleum hydrocarbons from the former JP-4 fuel storage tank at Building 2034 has resulted in significant smear zone contamination downgradient, affecting soils in the vicinity of Building 2035. Site investigation data suggest that separate releases at Building 2035 also may have occurred; however, insufficient data exist to definitively support separate releases. Regardless of the source of contamination, the proposed expansion of the bioventing system will provide oxygen to all contaminated soil to facilitate natural biodegradation of petroleum hydrocarbons.

Pilot test data have been used to design the expanded bioventing system to remediate contaminated soils. The expanded system will consist of the existing air injection vent wells (VWs) and two newly constructed VWs, to deliver oxygen throughout the remaining areas of unsaturated fuel-contaminated soils. In addition, two soil boreholes are proposed and may be converted to VWs if significant soil contamination is encountered. If significant soil contamination is not encountered, the boreholes will be converted to groundwater monitoring wells. Two new vapor monitoring points (VMPs) will also be constructed to monitor for contaminant reduction and oxygen influence in the soil gas. The expanded bioventing system will target smear zone contamination as well as vadose zone contamination.

This document is divided into eight sections including this introduction, and one appendix. Section 2 discusses site background and includes a discussion of existing characterization data. Section 3 provides the results of the extended pilot test conducted at both Buildings 2034 and 2035. Section 4 identifies the treatment area of the proposed expanded system; provides construction details of the expanded system; and recommends a proven, cost-effective approach for the remediation of the remaining hydrocarbon-contaminated soils at the site. Procedures for handling investigation-derived waste are described in Section 5, and Base support requirements are listed in Section 6. Section 7 provides key points of contact at Fairchild AFB, AFCEE, and Parsons ES; and Section 8 provides the references cited in this document. A design package for the expanded bioventing system is provided in Appendix A.

SECTION 2

SITE BACKGROUND

2.1 SITE HISTORY

Fairchild AFB is located approximately 12 miles west of Spokane, Washington and covers approximately 4,300 acres. The Base was established in 1942 as an Army repair depot, but was transferred to the Strategic Air Command (SAC) and assigned to the Fifteenth Air Force in 1947. In June 1992, the Air Combat Command (ACC) was established within the Air Force, and ACC assumed command of the Base. The Base is currently home to a detachment of the Washington Air National Guard (WANG), aircraft operational facilities, a weapons storage area, and a survival training school, and employs approximately 5,000 civilian and military personnel.

Building 2034 is the JP-4 fuels laboratory located approximately 70 feet west of Building 2035 and the underground fuel storage area (Figure 2.1). Building 2034 is set on a concrete foundation with no basement. In March 1990, an underground waste fuel tank immediately east of Building 2034 was removed. The tank was approximately 250 gallons in size and was used to store waste JP-4 fuel poured down the sink from the fuels lab. The excavation to remove the tank was approximately 9 feet square and 10 feet deep and was backfilled with clean, sandy fill. Approximately 24 cubic yards of soil was removed from the excavation; however, soils at the bottom and sides of the excavation were still visibly contaminated and smelled of fuel.

Building 2035 is the pump house for the fuel storage area, located north of the flightline (northeast of Taxiway No. 3) and north of hangar Building 1009. The area contains 10 underground storage tanks (USTs) extending to a depth of approximately 15 feet below ground surface (bgs), each capable of storing approximately 50,000 gallons of JP-4 fuel (Figure 2.1). One underground 2,000-gallon filter-separator tank is located east of the fuel tanks. The 10 fuel tanks have been in operation for approximately 40 years. The USTs are made of steel and currently have cathodic protection and automatic valves to prevent overfill. However, the area is heavily used, and during a Base-wide UST study conducted in December 1987, contaminated soils were discovered (Rittenhouse-Zeman & Associates [RZA], 1988).

The area around Buildings 2034 and 2035 is gravel covered and surrounded by a fence. The area within the fence is a designated Class I, Group D hazardous location due to potential for flammable fuel vapors.

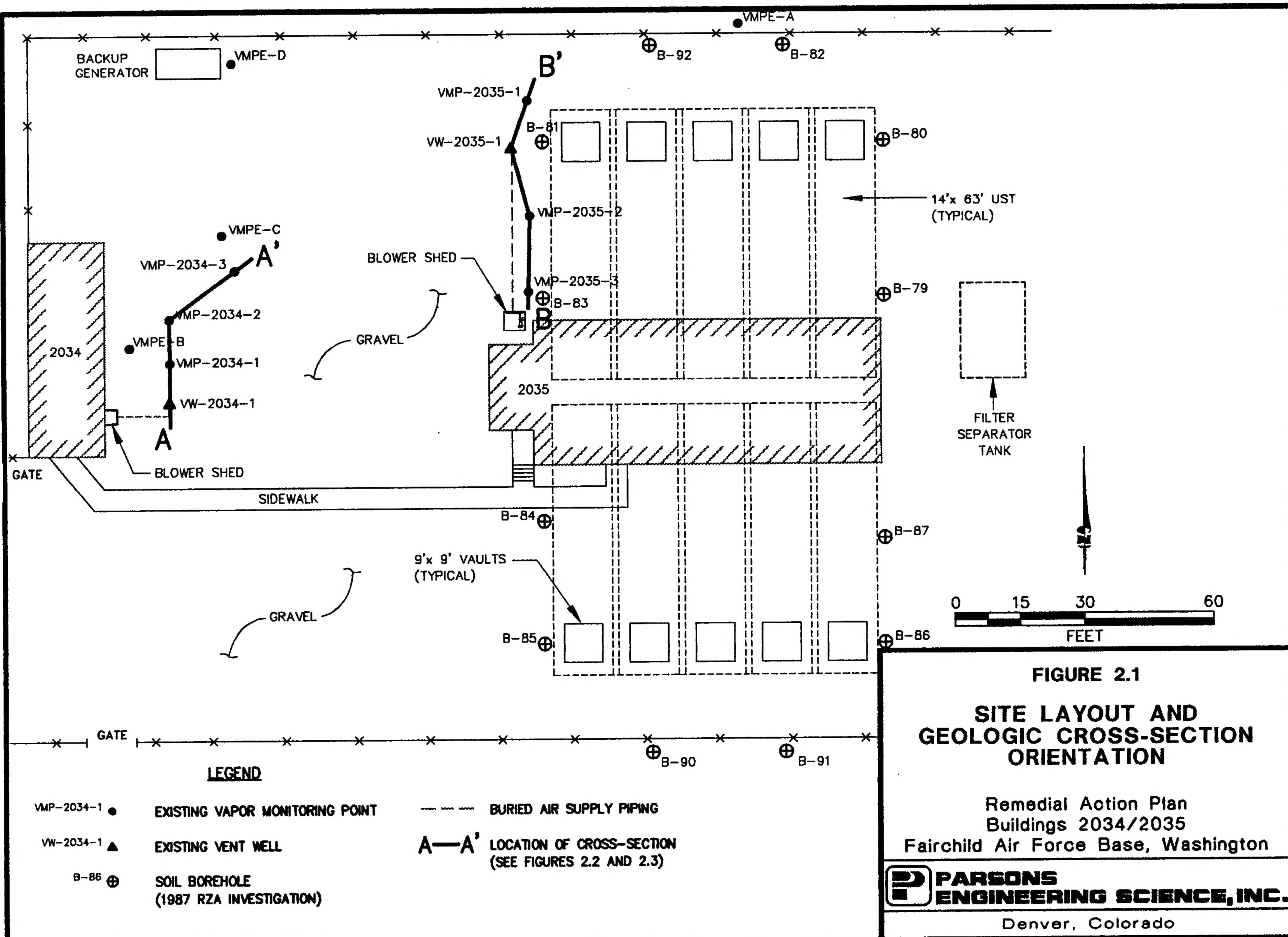


FIGURE 2.1

SITE LAYOUT AND GEOLOGIC CROSS-SECTION ORIENTATION

Remedial Action Plan
Buildings 2034/2035
Fairchild Air Force Base, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

K:\AFCEE\726876\FAIRCHLD\96DN0046, 02/09/96 at 09:49

2.2 SITE GEOLOGY AND HYDROGEOLOGY

Because the bioventing technology is applied to the unsaturated soils, this section will primarily address soils above the shallow aquifer. A more detailed discussion of the geology and hydrogeology can be found in the *Bioventing Pilot Test Work Plan for PS-2, PS-1A, PS-1B, Building 2034, and Building 2035* (ES, 1994).

Fairchild AFB is situated within the Columbia Plateau geomorphic region, an area of low topographic relief in northeastern Washington. The topography is created by nearly flat-lying Tertiary basalt flows that were extruded over deformed Paleozoic and Precambrian metasedimentary rocks. The Base is underlain by soils derived from Quaternary floodplain, glacial, and aeolian deposits, and weathered bedrock. The Quaternary deposits are comprised of fine-grained clays and silts with intercalated sandy silts, sandy clays, and sandy gravels. These deposits range in thickness from 1 to 46 feet and often increase in gravel content as they approach the underlying basalt bedrock. Underlying the Quaternary sediments is bedrock consisting of a sequence of nearly horizontal Tertiary basalt flows that are part of the Columbia River Basalt Group. Between the basalt flows are interbedded alluvial and lacustrine deposits of clay and fine-grained silts referred to collectively as the Latah Formation. These sediments were deposited in a changeable topography of lakes and streams created by intermittent episodes of lava flows during the Tertiary.

Unsaturated soils in the vicinity of Buildings 2034 and 2035 are primarily silty sand with occasional clay or gravel. Near Building 2035 and the 10 associated USTs, a medium to coarse, sandy fill occurs from ground surface to between 5 and 10 feet bgs. This fill was also found in boreholes B-82, B-90, B-91, and B-92, which are arrayed 19 feet north and south of the tanks (Figure 2.1). Below the fill is native soil, described as a sand or silty sand in most boreholes, which continues to 15 feet bgs, where the boreholes were terminated (RZA, 1988).

Figure 2.2 is geologic cross-section A-A' (traced on Figure 2.1) of the pilot test site at Building 2034 constructed using data from the bioventing pilot test VW and the three VMPs. The interpreted soil profile is shown along with organic vapor analyzer (OVA) readings, VW and VMP screened intervals, TRPH concentrations from laboratory analysis of soil samples, and initial oxygen levels in soil gas. The observed soil profile in VW-2034-1, VMP-2034-1, and VMP-2034-2 from surface to 0.5 to 1 foot bgs is a brown to dark-brown sand and gravel. Beneath this layer and below ground surface in VMP-2034-3 lies a brown to brownish-black silty sand with occasional gravel and/or clay. This silty sand extends to a depth of 8.5 to 9.5 feet bgs. This interval exhibited a noticeable fuel odor in VW-2034-1, VMP-2034-1, and VMP-2034-2. In VMP-2034-1 and VMP-2034-2, a dark brown to greenish brown-black sand layer underlies the silty sand. The sand continues to the bottom of the borehole in VMP-2034-1 and to 9.5 feet bgs in VMP-2034-2. A light-brown to brown clay occurs at the bottom of the soil profile in VW-2034-1, VMP-2034-2, and VMP-2034-3. This clay interval exhibited a noticeable fuel odor in VMP-2034-3 (ES, 1994).

Figure 2.3 is geologic cross-section B-B' (traced on Figure 2.1) of the pilot test site at Building 2035 using data from the pilot test VW and the three VMPs. The interpreted soil profile is shown along with OVA readings, VW and VMP screened intervals, TRPH concentrations from laboratory analysis of soil samples, and initial

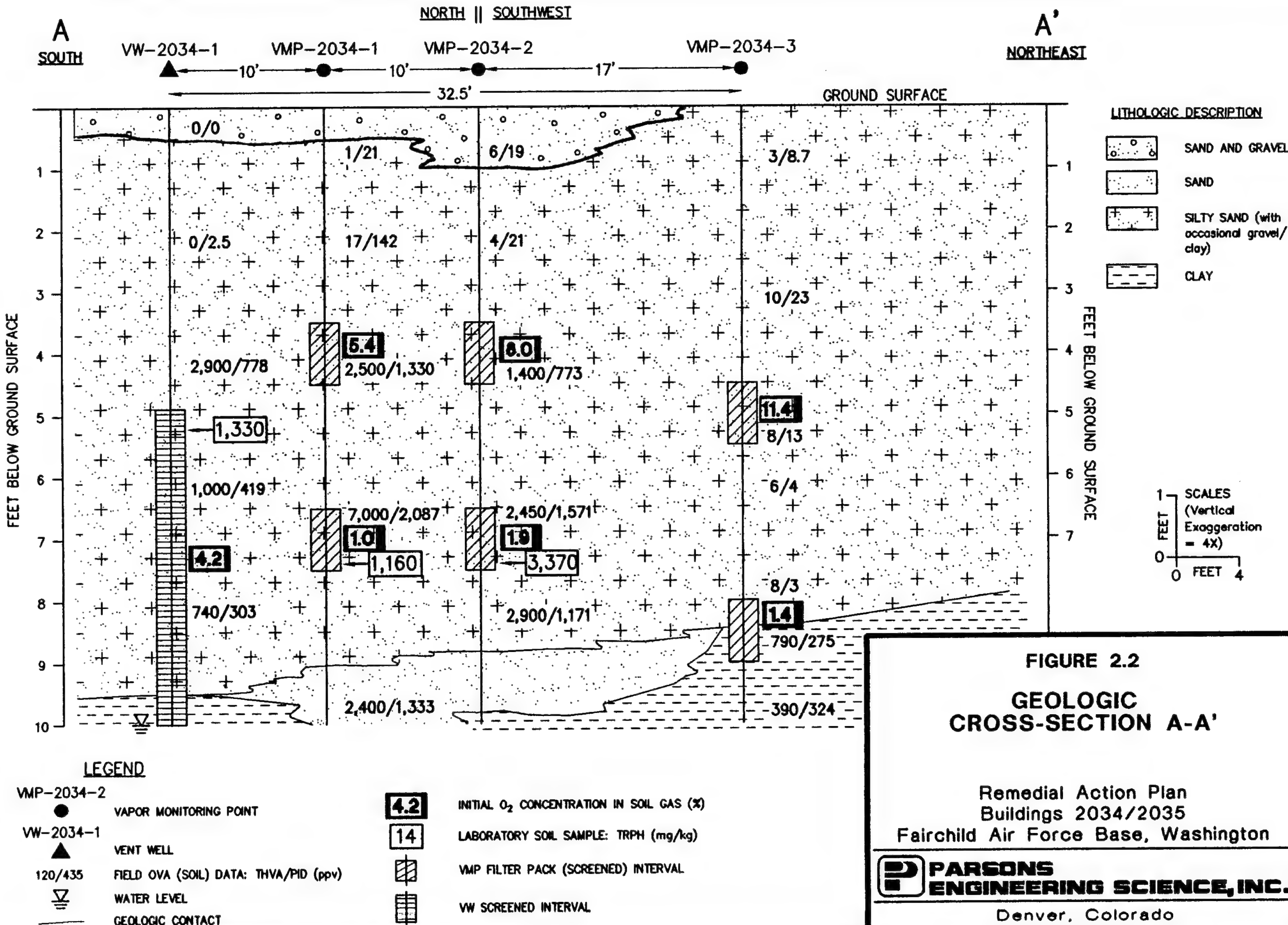


FIGURE 2.2

GEOLOGIC CROSS-SECTION A-A'

Remedial Action Plan
Buildings 2034/2035
Fairchild Air Force Base, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

K:\AFCEE\726876\FAIRCHLD\96DN0044, 02/09/96 at 07:42

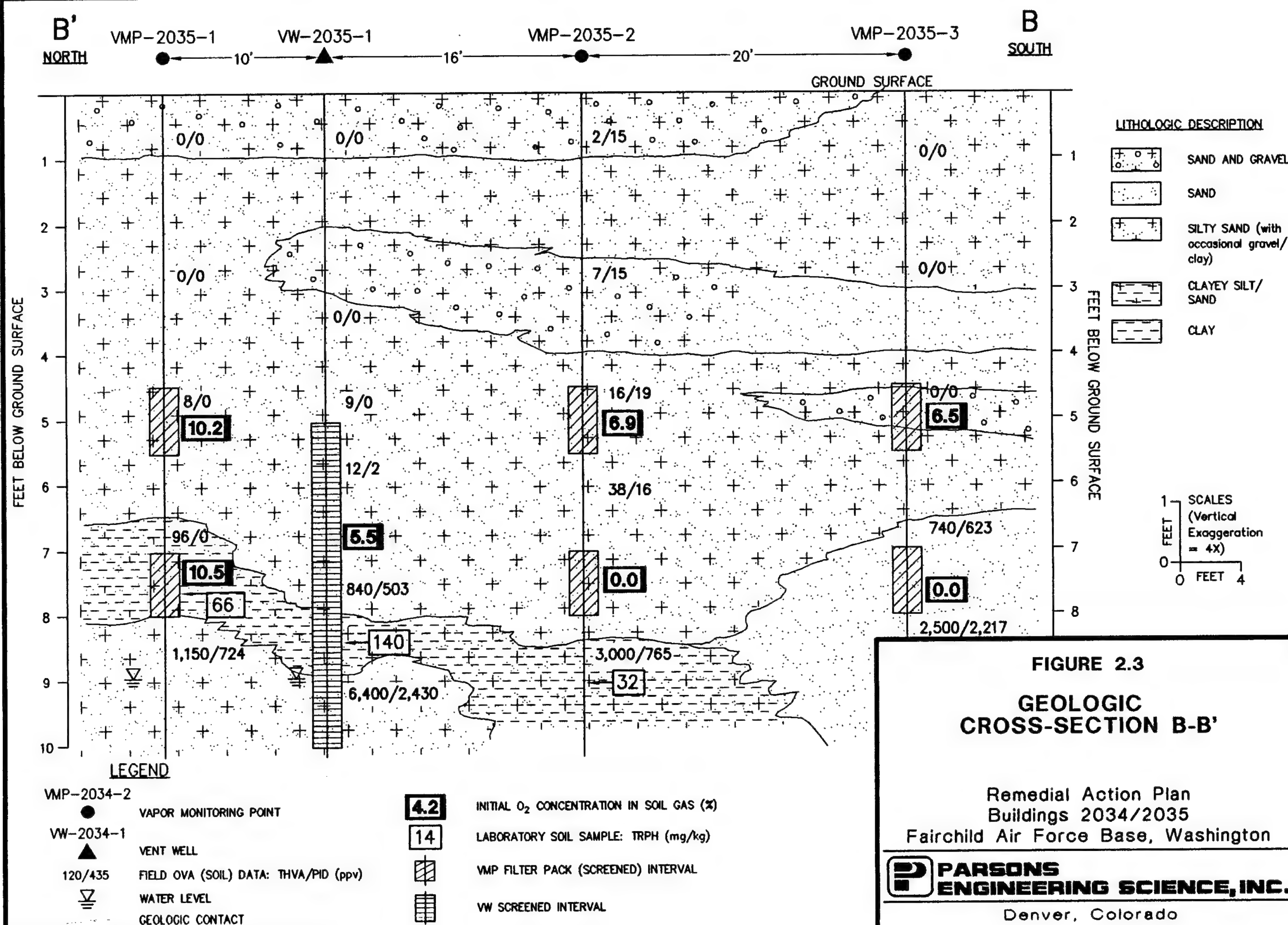


FIGURE 2.3

GEOLOGIC CROSS-SECTION B-B'

Remedial Action Plan
Buildings 2034/2035
Fairchild Air Force Base, Washington

K:\AFCEE\726876\FAIRCHLD\96DN0043, 04/23/96 at 15:28

oxygen levels in soil gas. The observed soil profile in VW-2035-1, VMP-2035-1, and VMP-2035-2 from surface to a depth of 1 foot bgs is a dark-brown silty sand with occasional gravel and/or clay. Beneath this sand and gravel layer and below ground surface in VMP-2035-3 is a brown to brownish black predominantly silty sand with occasional gravel and/or clay. This silty sand extends to a depth of 6.5 feet bgs in VMP-2035-1 and VMP-2035-3 and to approximately 8 feet bgs in VW-2035-1 and VMP-2035-2; however, a brown silty sand and gravel layer that grades laterally to a sand is found in VW-2035-1, VMP-2035-2 and VMP-2035-3 from about 2 to 4 feet bgs, and a brown silty sand and gravel layer is found in VMP-2035-3 from approximately 4.5 to 5.5 feet bgs. The extensive silty sand interval exhibited a noticeable fuel odor in VMP-2035-2 from approximately 6 to 8 bgs. A black-brown to gray-brown clayey silt/sand occurs in VMP-2035-1 from 6.5 to 8 feet bgs, in VW-2035-1 from approximately 7.5 to 8.5, and at the bottom of VMP-2035-2. Noticeable fuel odors were exhibited in VMP-2035-2 in this material. A black sand exists from 6.5 feet bgs to the bottom of the borehole in VMP-2035-3. This sand exhibited noticeable fuel odors.

Groundwater at the Base occurs in both the Quaternary sediments and basalt bedrock. Groundwater in the Quaternary sediments is under unconfined to locally semiconfined conditions. Pumping test data shows a good hydraulic connection between the Quaternary deposits and upper portion of the basalt bedrock, and together they are referred to as the overburden-shallow bedrock aquifer. This aquifer is poorly connected to a deeper bedrock aquifer encountered within 200 feet bgs. Average horizontal hydraulic conductivities in the Quaternary deposits, shallow bedrock basalt, and deep bedrock basalt are estimated at approximately 288, 0.74, and 0.38 feet per day (ft/day), respectively (ES, 1994).

Regional groundwater in the overburden-shallow bedrock aquifer generally flows from west to east, with a slight downward vertical flow component. This west to east movement occurs, in part, in response to a slightly southeast-dipping ground surface and underlying basalt bedrock surface. The groundwater flow direction in the immediate vicinity of the site appears to be north-northeast, based on water levels taken at monitoring wells south of the site in April 1992 (Halliburton NUS, 1993). The average overall lateral flow gradient across the Base is approximately 0.0045.

No groundwater monitoring wells are presently located in the immediate vicinity of Buildings 2034 and 2035. Based on field observations during drilling and pilot testing activities, it appears that the groundwater elevation fluctuates between 7 and 13.5 feet bgs. Groundwater was encountered at 13.5 feet bgs and 12 feet bgs in boreholes B-81 and B-83, respectively in 1987 (RZA, 1988). Groundwater was encountered at a depth of 10 feet bgs in VW-1 at Building 2034 in October 1993, but was not encountered at any of the VMPs, which also were drilled to 10 feet bgs (Figure 2.2). Groundwater was encountered in VW-1 and VMP-1 at Building 2035 at approximately 9 feet bgs in October 1993. Possible free-phase product was encountered at 9.5 to 10 feet bgs in VMP-1. During the 14-month bioventing testing event in May 1995, several VMPs at Building 2035 were flooded, indicating that groundwater may have risen 2 feet to a depth of 7 feet bgs.

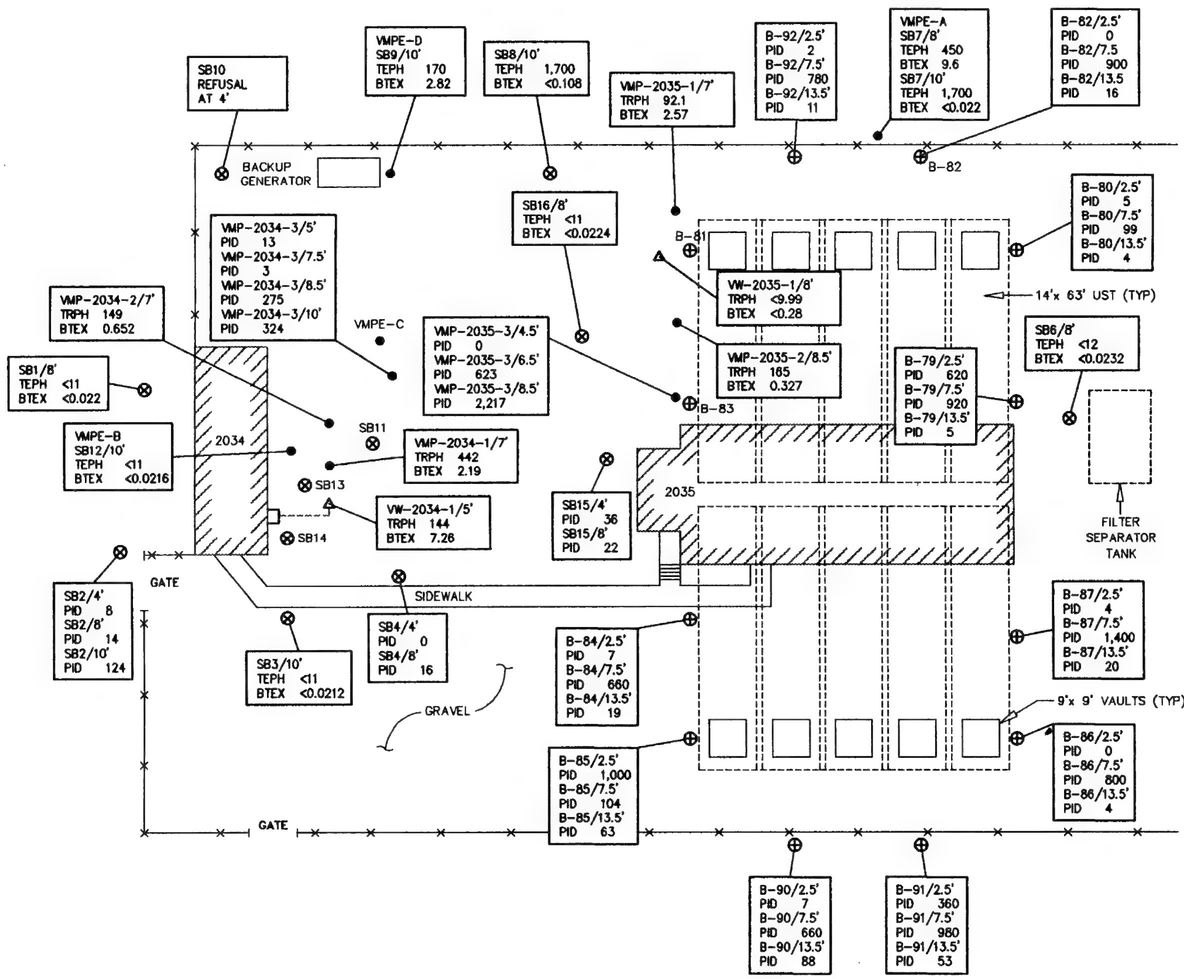
2.3 SITE CONTAMINANTS

Prior to installation of the pilot-scale bioventing systems, investigation at the sites had been limited to field screening of soil samples. No soil samples from Building 2035 and only one sample from Building 2034 had been analyzed for petroleum hydrocarbons by a laboratory. During tank removal operations at Building 2034, one soil sample was collected from the bottom of the excavation. The sample was analyzed for TRPH by US Environmental Protection Agency (USEPA) Method 418.1, and a level of 1,900 mg/kg TRPH was detected. During installation of the bioventing pilot test system components in 1993, additional soil sampling was performed. Selection of soil samples for laboratory analysis was based on field OVA readings, visual appearance, and odor. All boreholes drilled during the installation of the bioventing system at the Building 2034 site encountered evidence of hydrocarbon contamination. As shown on Figure 2.2, OVA readings greater than 2,500 parts per million volume basis (ppmv) were measured in VW-2034-1, VMP-2034-1, and VMP-2034-2. However, OVA readings appeared to decrease with distance from the original waste fuel tank location. OVA readings were lower in VMP-2034-3 and the abandoned borehole, although they were still above approximately 800 ppmv. The highest OVA readings were generally recorded within the silty sand at 7 to 9 feet bgs. Fuel odors were noted in all boreholes, and generally were stronger with depth.

Laboratory analysis of soil and soil gas samples documented hydrocarbon contamination in all boreholes advanced during installation of the bioventing system, although soil gas readings were lower in VMP-2034-3. The maximum contaminant levels in soil were 3,370 mg/kg TRPH (VMP-2034-2-7), 0.4 mg/kg benzene (VMP-2034-2-7), 6.9 mg/kg toluene (VMP-2034-1-7), 24 mg/kg ethylbenzene (VMP-2034-2-7), and 150 mg/kg total xylenes (VMP-2034-2-7). The maximum contaminant levels in soil gas were 29,000 ppmv TVH referenced to jet fuel (jf), 32 ppmv benzene, 100 ppmv toluene, 27 ppmv ethylbenzene, and 140 ppmv total xylenes (all at VMP-2034-1-7). Soil analytical results are summarized on Figure 2.2 and 2.4. Note however, that Figure 2.4 presents analytical results for soil samples collected after the extended bioventing pilot test.

No soil samples were collected during the UST survey at Building 2035 in 1987. However, based on photoionization detector (PID) readings collected during soil borehole drilling, contaminated soil appeared to be present on all sides of the tanks (RZA, 1988). PID readings greater than 900 ppmv were recorded in boreholes B-82, B-83, B-85, B-87, and B-91. The highest PID readings for each borehole, except B-81, were recorded at the 7.5 to 9.0 feet bgs interval. Figure 2.4 summarizes the PID readings from the 1987 boreholes except in areas where more recent analytical data were available.

All bioventing boreholes drilled at Building 2035 encountered evidence of hydrocarbon contamination. As shown on Figure 2.3, OVA readings greater than 1,100 ppmv were measured at depth in all VW and VMP boreholes. The highest OVA readings were generally recorded at the bottom of the boreholes between 8 and 10 feet bgs, just above the groundwater surface. Fuel odors were noted in all boreholes and generally were stronger with depth. Possible free product was encountered at 9.5 to 10 feet bgs in VMP-2035-1. Laboratory analysis of soil and soil gas samples documented hydrocarbon contamination in all boreholes. The maximum contaminant levels in soil



LEGEND

VMPE-A ●	VAPOR MONITORING POINT
VW-2034-1 ▲	VENT WELL
B-86 ⊕	SOIL BOREHOLE (1987)
SB3 ⊗	SOIL BOREHOLE (NOVEMBER 1995)
☐	SOIL SAMPLING RESULTS
SB3/10'	SAMPLE ID/DEPTH (feet below ground surface)
TRPH	TOTAL RECOVERABLE PETROLEUM HYDROCARBONS, (418.1)
TEPH	TOTAL EXTRACTABLE PETROLEUM HYDROCARBONS, (SW8015M)
BTEX	BENZENE, TOLUENE, ETHYLBENZENE AND TOTAL XYLENES (SW8020)
PID	PHOTOIONIZATION DETECTOR READING

NOTES:

1. TRPH, TEPH AND BTEX RESULTS REPORTED IN mg/kg. PID RESULTS REPORTED IN ppmv.
2. ANALYTICAL RESULTS FOR SAMPLES FROM VW-2034-1, VW-2035-1, VMP-2034-1, VMP-2034-2, VMP-2035-1 AND VMP-2035-2 ARE FROM SAMPLES COLLECTED AFTER 17 MONTHS OF BIOVENTING TREATMENT (AUGUST 1995). FOR ANALYTICAL RESULTS AT THESE LOCATIONS PRIOR TO TREATMENT, SEE TABLES 3.5 AND 3.6. ANALYTICAL RESULTS FOR SB1-SB4, SB6-SB10, SB12, SB15, AND SB16 ARE FROM SAMPLES COLLECTED IN NOVEMBER 1995 TO FURTHER DEFINE EXTENT OF CONTAMINATION.

0 15 30 60
FEET

FIGURE 2.4

SOIL ANALYTICAL AND FIELD SCREENING RESULTS

Remedial Action Plan
Buildings 2034/2035
Fairchild Air Force Base, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

K:\AFCEE\726876\FAIRCHLD\96DN0047 02/09/96 at 10:38

were 140 mg/kg TRPH, 1.1 mg/kg benzene, 2.6 mg/kg toluene, 3.4 mg/kg ethylbenzene, and 4.7 mg/kg total xylenes (all at VW-2035-1-8). The maximum contaminant levels in soil gas were 17,000 ppmv TVH-jf (VW-2035-1), 68 ppmv toluene (VMP-2035-3-7.5), 37 ppmv ethylbenzene (VMP-2035-1-7.5), and 150 ppmv total xylenes (VMP-2035-3-7.5). No benzene was detected in soil gas samples. The soil analytical results are summarized in Figures 2.3 and 2.4. Note however, that Figure 2.4 presents analytical results for soil samples collected after the extended bioventing pilot test.

Field observations, field screening results, and soil and soil gas analytical results indicated that the majority of the site soils were contaminated below 7 feet bgs. This indicates that petroleum hydrocarbons released into the subsurface migrated vertically to the groundwater surface, and were then spread downgradient through the advection of either dissolved or free-phase hydrocarbons. Fluctuating groundwater table elevations have caused a smearing of petroleum hydrocarbons near the groundwater surface.

Because previous investigation activities did not define the extent of smear zone soil contamination at Buildings 2034 and 2035, additional soil sampling was performed in November 1995 following more than a year of system operation. Fifteen soil boreholes, labeled SB1 through SB16 (SB5 was not advanced because of utilities), were advanced using a Geoprobe® truck-mounted soil sampling device. Soil samples were collected at 4 and 8 feet bgs of each borehole and at 10 feet bgs in some. All samples were screened for the presence of hydrocarbons using a PID. Samples from 10 locations were sent to the laboratory for analysis of total extractable petroleum hydrocarbons (TEPH) by Method SW8015 modified and BTEX by Method SW8020. The analytical results are presented on Figure 2.4. Benzene and toluene were not detected in any samples, and ethylbenzene was detected at only two locations and xylenes at one location. Field screening results are presented for those boreholes for which no analytical data are available. Field screening results from boreholes SB11, SB13, and SB14 are not displayed because of the close proximity of these boreholes to other sampled locations. No elevated PID readings were detected in soil samples from these locations.

The November 1995 soil sampling results indicate that the smear zone contamination extends north of the fencing around the Buildings 2034 and 2035 yard. Four VMPs, identified as VPME-A through -D, were installed during the November 1995 sampling event for use in monitoring the performance of the full-scale bioventing system. These VMPs have screened intervals at 4 and 8 feet bgs.

SECTION 3

BIOVENTING PILOT TEST RESULTS

The objectives of the initial bioventing pilot test were to:

- Assess the potential for supplying oxygen throughout the contaminated soil profile;
- To determine the rate at which indigenous microorganisms will degrade petroleum hydrocarbons when stimulated by oxygen-rich soil gas at this site; and
- To evaluate the potential for sustaining these rates of biodegradation until hydrocarbon contamination is remediated below regulatory approved standards.

Because bioventing has been demonstrated to be a feasible technology for this site, the pilot test data were used to design a full-scale remediation system (Section 4) to remediate the soils at the site, to minimize potential releases to groundwater/surface water, and to assure that contaminant levels throughout the site are below regulatory standards.

3.1 PILOT TEST CONFIGURATION

One VW (VW-2034-1) and three multi-depth VMPs (VMP-2034-1, VMP-2034-2, and VMP-2034-3) were installed at Building 2034 between 30 September and 4 October 1993. Locations of the VWs and VMPs are shown on Figure 2.1. Five boreholes were drilled at the site, and four were converted to either a VW or a VMP. One borehole was abandoned. VW-2034-1 was installed approximately 15 feet east of Building 2034. The screen was set between 5 and 10 feet bgs. VMP-2034-1, VMP-2034-2, and VMP-2034-3 were installed at distances from VW-2034-1 of 10 feet, 20 feet, and 32.5 feet, respectively. Site-specific construction details for the VMPs installed at Building 2034 are contained in Table 3.1.

One VW (VW-2035-1) and three multi-depth VMPs (VMP-2035-1, VMP-2035-2, and VMP-2035-3) were installed at Building 2035 between 4 and 12 October 1993. Locations of the VWs and VMPs are shown on Figure 2.1. VW-2035-1 was installed approximately 40 feet north of the western portion of Building 2035, immediately east of the UST complex (Figure 2.1). The screen was set between 5 and 10 feet bgs. VMP-2035-1, VMP-2035-2, and VMP-2035-3 were installed at distances from VW-2035-1 of 10 feet, 16 feet, and 33 feet, respectively. All three VMPs were located along a north-south line immediately east of the underground tank complex. Site-specific construction details for the VMPs installed at Building 2035 are contained in

TABLE 3.1
VW/VMP CONSTRUCTION DATA
BUILDINGS 2034/2035
REMEDIAL ACTION PLAN
FAIRCHILD AIR FORCE BASE, WASHINGTON

Well ID #	Borehole Total Depth (feet bgs)	VW Screen Interval (feet bgs)	Center of VMP Screen (feet bgs)	Filter Pack Interval(s) (feet bgs)	Bentonite Interval(s) (feet bgs)	Grout Interval(s) (feet bgs)
VW-2034-1	10	5.0 - 10.0	-	4.5 - 10.0	2.5 - 4.5	2.0 - 2.5
VMP-2024-1	10	-	4.0 7.0	3.5 - 4.5 6.5 - 7.5	2.0 - 3.5 4.5 - 6.5 7.5 - 10.0	1.5 - 2.0
VMP-2034-2	10	-	4.0 7.0	3.5 - 4.5 6.5 - 7.5	2.0 - 3.5 4.5 - 6.5 7.5 - 10.0	1.5 - 2.0
VMP-2034-3	10	-	5.0 8.5	4.5 - 5.5 8.5 - 9.0	2.0 - 4.5 5.5 - 8.5 9.0 - 10.0	1.5 - 2.0
VW-2035-1	10	5 - 10	-	4.5 - 10	2.5 - 4.5	2.0 - 2.5
VMP-2035-1	10	-	5.0 7.5	4.5 - 5.5 7.0 - 8.0	2.0 - 4.5 5.5 - 7.0 8.0 - 10.0	1.5 - 2.0
VMP-2035-2	10	-	5.0 7.5	4.5 - 5.5 7.0 - 8.0	2.0 - 4.5 5.5 - 7.0 8.0 - 10.0	1.5 - 2.0
VMP-2035-3	10	-	5.0 7.5	4.5 - 5.5 7.0 - 8.0	2.0 - 4.5 5.5 - 7.0 8.0 - 10.0	1.5 - 2.0

022/726876/170.XLS

Table 3.1. The centers of the screened intervals of each VMP are located at 5 and 7.5 feet bgs (ES, 1994).

Each VW was constructed using 4-inch inside-diameter (ID), Schedule 40 polyvinyl chloride (PVC) casing and slotted screen (0.040-inch slot size). The annular space adjacent to the screen was filled with 6-9 sieve size silica sand (filter pack material) from the bottom of the screen to approximately 0.5 foot above the top of the screen. A small amount of 100-mesh silica sand was added to the top of this interval to inhibit penetration of the overlying bentonite seal material into the filter pack interval. To prevent preferential air movement near the surface during pilot testing, a 2-foot thick annular bentonite seal was emplaced on top of the filter pack. The annulus of the well was then filled with a bentonite/cement grout to approximately 2 feet bgs. The upper 2 feet of annular space was left open to facilitate connecting subsurface piping for pilot testing and possible future full-scale remediation system implementation. The upper 2 feet of well casing was completed with a 4-inch-diameter Schedule 40 PVC tee and a 4-inch PVC cap (ES, 1994).

Each VMP was constructed using 0.25-inch-ID, Schedule 80 PVC casing and 1-inch-ID slotted screen intervals (0.020-inch slot size). Two casing strings/screens were installed in each VMP borehole to provide monitoring points at variable depths and contamination levels. Each of the screened intervals was 6 inches in length at the bottom of each individual PVC casing string and was centered in a 1-foot thick layer of 6-9 sieve size silica sand (filter pack material) topped with a thin layer of 100-mesh silica sand. These filter pack intervals were sealed above and below with bentonite. A sampling valve was attached to the top of each casing string. In VMP-2034-1 and VMP-2035-1, thermocouples were installed adjacent to the screens at the shallowest and deepest depths to allow measurement of soil temperature (ES, 1994).

A background VMP, VMP-B1, was installed to monitor soil gas conditions in clean contaminated soil. VMP-B1 was installed near the northwest corner of Building 1009, approximately 230 feet south of Buildings 2034 and 2035. No contamination was observed in the physical feature of the soil or determined based on the OVA readings from this location. No groundwater was encountered during drilling operations at this site. VMP-B1 was installed following procedures described in the protocol document. The centers of the screened intervals at VMP-B1 are located at 5.0 and 7.5 feet bgs.

Fixed 1.0-horsepower (HP) Gast© regenerative blower units (model R4) were installed at Buildings 2034 and 2035 for the extended pilot tests. The regenerative blower unit at Building 2034 was installed on 15 October 1993, and began operation on 9 March 1994 for the extended pilot test. At the time of installation, the blower unit was reported to be injecting approximately 28 standard cubic feet per minute (scfm). However, the accuracy of the injection flow rate data is questionable because the rates were estimated using blower curves and measuring bleed flow rather than direct readings of the injection flow rate. The unit is powered via a line, installed by an electrical subcontractor, that runs to the blower from inside Building 2034 (Building 2.1).

The regenerative blower unit at Building 2035 was installed on 21 October 1993, and began operation on 9 March 1994 for the extended pilot test at Building 2035. At the time of installation, the blower unit was injecting approximately 25 scfm. Again,

the accuracy of the injection flow rate data is questionable for the reasons stated above for the Building 2034 blower. The unit is powered via a line, installed by an electrical subcontractor, that runs to the blower from the inside of Building 2035 (Figure 2.1). Parsons ES personnel provided an operations and maintenance (O&M) data collection sheet and blower maintenance manual for each site to Base personnel.

3.2 INITIAL SOIL GAS CHEMISTRY

Prior to initiating air injection, the VW and all VMPs were purged until oxygen levels had stabilized, and then initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable OVAs as described in the AFCEE bioventing protocol document (Hinchee *et al.*, 1992). Depleted oxygen levels and increased carbon dioxide levels were found in soil gas at the VWs and at all VMP screened intervals, indicating soil contamination and natural biological activity in contaminated soil. The initial soil gas chemistry results measured at Building 2034 and Building 2035 are summarized in Table 3.2. TVH for soil gas samples (both field instrument measurements and laboratory analytical results) and TRPH and BTEX concentrations for soil samples are also provided to demonstrate the relationship between oxygen levels and the contaminated soils. Initial oxygen levels are also shown on geologic cross-sections A-A' and B-B' (Figures 2.2 and 2.3).

In contrast, soil gas from the background VMP (VMP-B1), has oxygen concentrations of 17.0 percent and carbon dioxide concentrations of 2.2 percent at both the 5 and 7.5 feet bgs depths (ES, 1994). These initial soil gas results demonstrated that oxygen depletion and carbon dioxide accumulation in contaminated soils resulted from biodegradation of hydrocarbon contaminants rather than from naturally occurring soil organic and abiotic processes.

3.3 *IN SITU* BIODEGRADATION RATES

In situ respiration testing was conducted to determine the biodegradation rates of indigenous bacteria in contaminated subsurface soils. Table 3.3 shows the results of three *in situ* respiration testing events conducted as part of the bioventing pilot tests (initial, 14 months, and 17 months) for Buildings 2034 and 2035.

The initial and 17-month *in situ* respiration tests were performed by injecting ambient air (20.8 percent oxygen) at a rate of approximately 1 scfm into selected VMP screened intervals for at least 20 hours in order to oxygenate surrounding soils. After air injection was ceased, oxygen, carbon dioxide, and TVH levels in selected screened intervals were measured in soil gas. The bioventing systems had been turned off for several days prior to the 17-month test to allow soil gas to reach equilibrium. The 14-month *in situ* respiration tests were performed by turning off the blower system and monitoring oxygen, carbon dioxide, and TVH levels in selected screened intervals.

Results from the *in situ* respiration tests indicated that the VWs and all of the VMP screened intervals in hydrocarbon-contaminated soils have active microorganism populations. The biodegradation rate estimates presented in Table 3.3 are based on calculated air-filled porosities (liters of air per kg of soil) and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded.

TABLE 3.2

INITIAL SOIL GAS CONDITIONS

BUILDINGS 2034/2035

REMEDIAL ACTION PLAN

FAIRCHILD AIR FORCE BASE, WASHINGTON

Sample Location	Depth (feet)	O_2 (percent)	CO_2 (percent)	TVH-jf (ppmv) [a/]	TVH (ppmv) [b/]
VW-2034-1	5-10	4.2	8.1	23,000	>10,000
VMP-2034-1	4	5.4	7.6		>10,000
VMP-2034-1	7	1.0	10.2	29,000	>10,000
VMP-2034-2	4	8.0	7.5		1,100
VMP-2034-2	7	1.9	10.6		>10,000
VMP-2034-3	5	11.4	5.2		280
VMP-2034-3	8.5	1.4	12.5	570	150
VW-2035-1	5-10	5.5	9.5	17,000	>10,000
VMP-2035-1	5	10.2	4.9		2,800
VMP-2035-1	7.5	10.5	5.1	14,000	>10,000
VMP-2035-2	5	6.9	9.0		880
VMP-2035-2	7.5	0.0	10.7		6,600
VMP-2035-3	5	6.5	9.0		750
VMP-2035-3	7.5	0.0	13.0	14,000	>10,000

[a/] TVH-jf = total volatile hydrocarbons as jet fuel (EPA Method TO-3); ppmv = parts per milloin, volume basis.

[b/] TVH = total volatile hydrocarbons (field instrument).

022/726876/170.XLS

TABLE 3.3
RESPIRATION AND DEGRADATION RATES
BUILDINGS 2034/2035
REMEDIAL ACTION PLAN
FAIRCHILD AFB, WASHINGTON

Location-Depth (feet below ground surface)	Initial			14-Month [b]			17-Month		
	K_o (% O_2/hour)	Degradation Rate (mg/kg/year)[a]	Soil Temperature (°C)	K_o (% O_2/hour)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/hour)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
Building 2034									
VW1 (5'-10')	0.78	2,500	NS [c]	NS	NS	NS	0.05	170	NS
VMP1-4	0.96	2,900	12	0.45	1,400	NS	1.26	3,800	NS
VMP1-7	0.72	2,700	14	0.08	260	NS	0.17	640	NS
VMP2-4	0.50	1,600	NS	NC [d]	NC	NS	0.11	340	NS
VMP2-7	1.08	2,100	NS	0.19	480	NS	0.29	550	NS
VMP3-5	0.12	380	NS	0.003	10	NS	0.02	70	NS
VMP3-8.5	0.46	2,000	NS	NC [e]	NC	NS	0.06	180	NS
Building 2035									
VW1 (5'-10')	0.39	1,700	NS	NS	NS	NS	0.06	360	NS
VMP1-5	0.22	690	14.3	NS [f]	NS	NS	0.31	990	NS
VMP1-7.5	0.23	750	14.6	NC [g]	NC	NS	0.52	830	NS
VMP2-5	0.11	350	NS	NC [h]	NC	NS	0.02	60	NS
VMP2-7.5	0.55	1,400	NS	NS [f]	NS	NS	0.13	390	NS
VMP3-5	0.35	1,100	NS	0.06	190	NS	0.13	420	NS
VMP3-7.5	0.72	3,200	NS	NS [f]	NS	NS	1.32	6,100	NS

[a] Milligrams of hydrocarbons per kilogram of soil per year.
[b] Assumes moisture content of the soil is average of initial and final moistures.
[c] NS = Not sampled.
[d] NC = Not calculated. Monitoring point was not sufficiently aerated during testing event.
[e] Oxygen utilization was not observed at this location during the 14-month testing event.
[f] Monitoring point was flooded during 14-month testing event.
[g] Respiration test readings suspect.
[h] Oxygen utilization not observed during 14-month testing event.

022/726876/170.XLS

Because the oxygen levels in VMP-B1 at 5 and 7.5 feet bgs were below 18 percent, a background well respiration test is required at VMP-B1 according to protocol document procedures (Hinchee *et al.*, 1992). Although it cannot be assumed that inorganic or natural carbon sources did not contribute to oxygen uptake during the *in situ* respiration tests, the readings from VMP-B1 suggest that any oxygen uptake attributable to inorganic or natural carbon sources is probably minimal.

3.4 OXYGEN INFLUENCE/AIR PERMEABILITY

Air permeability/radius of oxygen influence tests were performed at the Building 2034 and 2035 bioventing pilot test sites to determine the pressure response in the formation induced by pressurizing the VWs and to determine the volume of subsurface soils that could be oxygenated from air injection into a single VW. The depth and radius of oxygen influence in the subsurface resulting from air injection into the VW is the primary design parameter for extended bioventing systems. The pilot test data determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

The air permeability test was conducted at the Building 2034 site on 13 October 1993, according to protocol document procedures. Air was injected into VW-2034-1 for approximately 5 hours at a flow rate of 13 scfm with an average pressure at the well head of 28 inches of water. Due to the very quick pressure response and the short length of time required to achieve steady-state conditions at the VMPs, the steady-state response method was used to calculate air permeability values, as detailed in the protocol document (Hinchee *et al.*, 1992). Using the steady-state method, the permeability value for site soils is approximately 9 darcys, typical for the silty sands that are predominant at the site (see Figure 2.2). The calculated permeability value indicates that the site soils are sufficiently permeable to air for the bioventing technology.

Table 3.4 presents the change in soil gas oxygen levels during the air permeability test and also over the extended pilot test. Increases in soil gas oxygen levels occurred at most of the VMP screens, indicating successful oxygen transport at a radial distance of at least 32.5 feet from the VW. This measured radius of oxygen influence is in close agreement with the radius of pressure influence calculated from the air permeability test data.

The air permeability test was conducted at the Building 2035 site between 19 and 20 October 1993, according to protocol document procedures. Air was injected into VW-2035-1 for approximately 20 hours at a flow rate of 18 scfm with an average pressure at the well-head of 19 inches of water. The magnitude of the pressure response at this site was low; the maximum response in VMP-2035-1, the monitoring point closest to the VW, was only 0.25 inch of water. Due to the quick pressure response and the short length of time required to achieve steady-state conditions at the VMPs, the steady-state response method was used to calculate air permeability values, as detailed in the protocol document (Hinchee *et al.*, 1992). Using the steady-state method, the permeability values for site soils ranged from 17 to 19 darcys, typical for the silty sands that are predominant at the site (see Figure 2.3). The calculated permeability value indicates that the site soils are sufficiently permeable to air for the bioventing technology.

TABLE 3.4

INFLUENCE OF AIR INJECTION ON OXYGEN CONCENTRATIONS

BUILDINGS 2034/2035

REMEDIAL ACTION PLAN

FAIRCHILD AIR FORCE BASE, WASHINGTON

Monitoring Location	Depth (feet)	Distance from VW-1 (feet)	Initial O_2 (percent)	Permeability Test Final O_2 [a/] (percent)	14-Month Test O_2 [b/] (percent)	17-Month Test O_2 [c/] (percent)
VMP-2034-1	4	10	5.4	16.2	20.0	18.3
VMP-2034-1	7	10	1.0	18.2	20.7	19.6
VMP-2034-2	4	20	8.0	9.5	6.6	7.2
VMP-2034-2	7	20	1.9	10.0	15.8	17.5
VMP-2034-3	5	32.5	11.4	13.0	19.0	2.0
VMP-2034-3	8.5	32.5	1.4	0.2	16.9	18.0
VMP-2035-1	5	10	10.2	9.0	20.7	20.5
VMP-2035-1	7.5	10	10.5	9.2	20.7	19.0
VMP-2035-2	5	16	6.9	4.5	15.8	17.5
VMP-2035-2	7.5	16	0.0	2.0	20.8	20.2
VMP-2035-3	5	33	6.5	1.0	18.4	16.5
VMP-2035-3	7.5	33	0.0	1.5	NM [d/]	2.0

[a/] Based on oxygen concentrations observed at end of air permeability tests performed in October 1993.

[b/] Oxygen concentrations observed at begining of 14-month respiration test, 11 May 1995.

[c/] Oxygen concentrations observed prior to system shut down for 17-month respiration test, 26 June 1995.

[d/] NM = Not measured. Monitoring point was flooded at the time of sampling.

Table 3.4 presents the change in soil gas oxygen levels during the air permeability test and over the extended pilot test. Increases in soil gas oxygen levels were observed at all of the VMP screens, indicating successful oxygen transport at a radial distance of at least 33 feet at all depths.

3.5 SOIL AND SOIL GAS SAMPLING RESULTS

Soil and soil gas samples were collected during the installation of the pilot-scale bioventing systems in October 1993 to determine baseline contaminant concentrations at the VW and MP locations. Samples were collected again in August 1995, after 17-months of bioventing. Soil samples were collected from the same depths from boreholes immediately adjacent to the original boreholes, and soil gas samples were collected from the discrete VMP intervals originally sampled. The bioventing systems were turned off several days prior to collecting soil gas samples to allow soil gas to reach equilibrium. As shown in Tables 3.5 and 3.6, significant reductions in petroleum hydrocarbon concentrations were observed.

At Building 2034, soil gas TVH concentrations at the VW and VMP-2034-1-7 were reduced from 23,000 and 29,000 ppmv to 0.52 and 6.4 ppmv, respectively. At VMP-2034-3-8.5, soil gas TVH concentrations were reduced from 570 to 260 ppmv over the extended treatment period. Soil gas BTEX concentrations were also significantly reduced at all sample locations, most notably at VMP-2034-1-7, where the total BTEX was reduced from 299 ppmv to nondetect. Soil sampling results at Building 2034 exhibited similar trends, with TRPH concentrations decreasing by an order of magnitude at all locations. BTEX concentrations were significantly reduced at VMP-2034-1-7 and VMP-2034-2-7; total BTEX concentrations were reduced 97.7 and 99.6 percent at VMP-2034-1-7 and VMP-2034-2-7, respectively.

At Building 2035, soil gas TVH concentrations were reduced by two orders of magnitude at VW1 and by one order of magnitude at VMP-2035-1-7.5 and VMP-2035-3-7.5 over the extended treatment period. Soil gas BTEX concentrations were reduced at all sample locations, resulting in reductions in total BTEX ranging from 69.5 to 98.0 percent. Soil sampling results indicated reduction in hydrocarbon concentrations at VW-2035-1, however, TRPH and BTEX concentrations at VMP-2035-1-7 and VMP-2035-2-8.5 increased slightly. Both the initial and final concentrations were low, and the increase may be the result of groundwater table fluctuations smearing contamination.

3.6 POTENTIAL AIR EMISSIONS

The potential for surface air emissions of volatile organics was investigated during the bioventing pilot tests. Surface measurements were taken using an isolation flux chamber and followed protocols established by the USEPA's Environmental Monitoring Systems Laboratory (USEPA, 1986). Hydrocarbon emissions were measured using TVH analyzer and laboratory analyses. Surface air samples also were shipped to Air Toxics, Ltd. for analysis of TVH-jf and BTEX.

Five surface measurement points were located radially around each VW and at distances expected to be under the influence of air injection. At Building 2034, three of the surface measurement points were arrayed around VW-2034-1 roughly 120

TABLE 3.5
BUILDING 2034
SOIL AND SOIL GAS ANALYTICAL RESULTS
REMEDIAL ACTION PLAN
FAIRCHILD AFB, WASHINGTON

Analyte (Units) [a/]	Sample Locations-Depth (feet below ground surface)					
	VW1 (5-10)		VMP1-7		VMP3-8.5	
Soil Gas Hydrocarbons	Initial [b/]	17-Month [c/]	Initial	17-Month	Initial	17-Month
TVH-jf (ppmv)	23,000	0.52	29,000	6.4	570	260
Benzene (ppmv)	<1.1	<0.002	32	<0.002	<0.55	0.048
Toluene (ppmv)	<1.1	<0.002	100	<0.002	2.1	0.6
Ethylbenzene (ppmv)	18	<0.002	27	<0.002	1.5	0.88
Xylenes (ppmv)	120	0.006	140	<0.002	8	4.9
	VW1-5		VMP1-7		VMP2-7	
Soil Hydrocarbons	Initial [d/]	17-Month [e/]	Initial	17-Month	Initial	17-Month
TRPH (mg/kg)	1,330	144	1,160	442	3,370	149
Benzene (mg/kg)	0.075	0.39	0.28	<0.050	0.4	<0.050
Toluene (mg/kg)	0.41	0.87	6.9	0.11	3	0.065
Ethylbenzene (mg/kg)	0.68	2.1	13	0.23	24	0.067
Xylenes (mg/kg)	5.2	3.9	77	1.8	150	0.47
Moisture (%)	9.5	11.5	8.1	9.3	14	11.9

[a/] TVH-jf = total volatile hydrocarbons as jet fuel: ppmv = parts per million, volume per volume;
TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

[b/] Initial soil gas samples collected on 12 October 1993. Blower system was started 9 March 1994.

[c/] Final soil gas samples collected on 15 August 1995.

[d/] Initial soil samples collected on 30 September and 1 October 1993.

[e/] Final soil samples collected on 15 August 1995.

TABLE 3.6
BUILDING 2035
SOIL AND SOIL GAS ANALYTICAL RESULTS
REMEDIAL ACTION PLAN
FAIRCHILD AFB, WASHINGTON

Analyte (Units) [a]	Sample Locations-Depth (feet below ground surface)					
	VW1 (5-10)		VMP1-7.5		VMP3-7.5	
Soil Gas Hydrocarbons	Initial [b]	17-Month [c]	Initial	17-Month	Initial	17-Month
TVH-jf (ppmv)	17,000	110	14,000	1,700	14,000	1,200
Benzene (ppmv)	< 1.0	0.48	< 1.0	4.7	< 1.0	3.5
Toluene (ppmv)	< 1.0	0.64	< 1.0	6.0	68	13
Ethylbenzene (ppmv)	28	0.23	37	1.9	23	5.5
Xylenes (ppmv)	51	0.28	58	17	150	13
	VW1-8		VMP1-7		VMP2-8.5	
Soil Hydrocarbons	Initial [d]	17-Month [e]	Initial [f]	17-Month	Initial	17-Month
TRPH (mg/kg)	140	<9.99	66	92.1	32	165
Benzene (mg/kg)	1.1	<0.050	< 0.00056	0.120	< 0.0006	<0.050
Toluene (mg/kg)	2.6	<0.050	0.0090	0.570	0.053	<0.050
Ethylbenzene (mg/kg)	3.4	<0.050	< 0.00056	0.970	0.0013	0.067
Xylenes (mg/kg)	4.7	<0.130	0.0014	0.910	0.021	0.160
Moisture (%)	6.8	1.8	9.7	14.9	12	10.2

[a] TVH-jf =total volatile hydrocarbons as jet fuel: ppmv = parts per million, volume per volume;
TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

[b] Initial soil gas samples collected on 18 October 1993. Blower system was started on 9 March 1994.

[c] Final soil gas samples collected on 15 August 1995. Blower system was shut down approximately 4 days prior to soil gas sampling to allow soil gas to come to equilibrium with soils.

[d] Initial soil samples collected on 4 through 6 October 1993.

[e] Final soil samples collected on 15 August 1995.

[f] Sample was analyzed one day past the hold time of 14 days.

degrees apart and located at a distance of 12 feet from the VW. The remaining two measurement points were spaced at 24 and 36 feet from VW-2034-1 in order to characterize the radial extent of any emissions. The air injection flow rate was approximately 15 scfm. At Building 2035, three of the surface measurement points were arrayed around VW-2035-1 roughly 120 degrees apart and located at a distance of 11 feet from the VW. The remaining two measurement points were spaced at 22 and 33 feet from VW-2035-1 in order to characterize the radial extent of any emissions. The air injection flow rate was approximately 18 scfm.

Results from the TVH analyzer were recorded in the field notebook. In order to determine the TVH-jf and BTEX content of potential emissions, two surface air samples were collected from each site for laboratory analysis, one prior to air injection and one 4 hours after initiation of air injection at the same location. Using very conservative assumptions that the hydrocarbon emission rates would not decrease over time and that the emission rates for the surface points nearest the injection well apply throughout the entire radius of influence, the potential total hydrocarbon emissions are estimated at 0.017 pound per hour (lb/hr) (150 pounds per year [lb/yr]) for Building 2034 and 0.027 lb/hr (240 lb/yr) at Building 2035. Because no benzene emissions were detected, potential benzene emissions are expected to be negligible.

To estimate the total potential emissions from the full-scale bioventing, several extremely conservative assumptions were made. It was assumed that the long-term emissions would be the same as the highest emission rate initially measured (240 lb/yr). This is conservative because emission rates most likely decrease over time as volatile hydrocarbons are degraded and emitted. It also was assumed that this emission rate would apply throughout the entire treatment area. This is conservative because the flux monitoring was performed near the source areas of contamination where concentrations of volatile hydrocarbons are expected to be greatest. Assuming a uniform emission rate of 240 lb/yr for each VW, the total annual emissions of volatile hydrocarbons is estimated at 1,440 lb/yr. Again, because benzene emissions were not detected during the initial flux testing event, potential benzene emissions are expected to be negligible.

There is no allowable limit for TVH set forth by the Washington Department of Ecology for small-quantity emissions in Washington Administrative Code (WAC) 173-460-080; however, the allowable limits for toluene, ethylbenzene, and xylenes are 43,748 lb/yr each. The estimated TVH emission rate is well below the limits set forth for these individual components. For benzene, the allowable limit is 20 lb/yr; however, no benzene emissions were detected during monitoring. Even assuming that the soils within the entire fenced area surrounding Buildings 2034 and 2035 (260 feet by 165 feet) had benzene concentration of 1.1 mg/kg (the maximum detected concentration) across 5 feet of the unsaturated soil interval, the total mass of benzene potentially emitted would be 25 pounds. Therefore, approaching the 20-lb/yr limit would be highly unlikely.

3.7 RECOMMENDATION FOR FULL-SCALE BIOVENTING

Based on the positive results of the 17-month bioventing pilot tests, AFCEE has provided funding for the design and installation of an expanded bioventing system that will remediate the remaining contaminated soils associated with Buildings 2034 and 2035. AFCEE has retained Parsons ES to continue bioventing services at Fairchild

AFB and to complete the design and installation of an expanded bioventing system. Based on the initial pilot test results, available analytical data, and recently completed soil sampling, Parsons ES has prepared a conceptual full-scale upgrade design that will employ the existing VWs and two additional VWs. Two additional VMPs also will be installed to ensure oxygen is being delivered to contaminated soils. In addition, four more boreholes will be installed to further define the extent of contamination. If through field screening observations it is determined that significant soil contamination is present in these boreholes, VWs will be installed. Section 4 provides details on the design, construction, and operation of the expanded system. A design package has been prepared for construction of the system and is included in Appendix A of this RAP.

SECTION 4

EXPANDED BIOVENTING SYSTEM

The purpose of the expanded bioventing system is to provide oxygen to stimulate aerobic biodegradation of the remaining soil contamination present at Buildings 2034 and 2035. The existing VWs and two additional air injection VWs will be used to provide oxygen to oxygen-depleted, unsaturated, contaminated soils at the site. The full extent of soil contamination has not been defined; therefore, four additional soil boreholes will be advanced, and if significant soil contamination is observed, VWs will be installed in these boreholes. These additional VWs may be manifolded to the blower system if it is feasible. The presence of underground utilities and fuel transfer lines may inhibit the manifolding of all VWs to the proposed blower system. If significant soil contamination is not observed, groundwater monitoring wells may be installed in the boreholes. Two additional VMPs will also be installed to ensure that oxygen is being delivered to contaminated soils. System design details are provided in Appendix A.

4.1 OBJECTIVES

Following its installation, the primary objectives for the expanded bioventing system will be to:

- Optimize the system to fully aerate the unsaturated subsurface in areas at the site designated for bioventing remediation;
- Reduce the existing contaminant levels to below acceptable regulatory cleanup criteria (State of Washington Method A levels of 0.5 mg/kg benzene, 40 mg/kg toluene, 20 mg/kg ethylbenzene, 20 mg/kg total xylenes, and 200 mg/kg TPH represent preliminary cleanup goals [Washington State Department of Ecology, 1991]);
- Eliminate the potential for contamination to migrate and adversely affect groundwater quality at these sites by removing the contaminant source from vadose soils; and
- Provide the most cost-effective remediation alternative for these sites.

4.2 BASIS OF DESIGN

Site investigation data, pilot test data, and experience at other bioventing sites provide the main elements of the basis of design. The expanded bioventing system was designed to provide oxygen to areas of significant soil contamination. Both vadose zone and smear zone contaminated soils have been targeted. Site investigation data

available to date have not fully defined the extent of soil contamination. Therefore, the design includes installation of four additional soil boreholes to further define the extent of soil contamination at this site. If, based on field observations during installation of the soil boreholes, significant vadose zone contamination is encountered then VWs will be installed. If significant vadose zone contamination is not encountered in a soil borehole, either a monitoring well will be installed or the borehole will be abandoned.

Pilot test data, such as operating pressure and radius of oxygen influence, were considered during design development. These data were considered in the spacing of VWs and sizing of a full-scale blower system. In addition to the pilot test data from these sites, experience at other sites with similar soil types was considered in design development. Experience at other sites was used only where there were shortcomings in the pilot test data, such as uncertainty in accuracy of the flow rate data.

The significant design parameters and considerations are as follow:

- A radius of oxygen influence of 40 feet was used resulting in the spacing of VWs 80 feet apart. However, near the areas of greatest apparent vadose zone contamination (near the source area at Building 2034) VWs were spaced more closely.

- An air injection pressure of 30 inches of water was assumed in sizing the full-scale bioventing blower. This is consistent with pressures observed during the extended pilot test.

- An air injection flow rate of 15 scfm per VW was assumed based on experience at other sites.

The full-scale design utilizes the existing blower used for the pilot test at Building 2034 to continue to provide air to the VW installed for the pilot test (VW-2034-1). The blower used for the pilot test at Building 2035 will be replaced with a larger blower that will supply the Building 2035 pilot test VW (VW-2035-1) and up to four additional VWs. This larger blower was sized assuming it will provide air flow to a total of five VWs.

The locations of the two additional VMPs were selected such that they would provide information as to the extent of smear zone contamination, would be useful in evaluating the magnitude of contaminant reduction through soil gas sampling, and would provide important oxygen influence data. The proposed VMPs both will be located in potential "dead zones" outside the design radius of oxygen influence.

Although field screening of soil samples collected during the 1987 investigation indicated that soil contamination existed near the perimeter of the tanks (RZA, 1988) and therefore probably beneath the tanks, the soils beneath the tanks at Building 2035 are not targeted for treatment by the full-scale bioventing system. The presence of the USTs would significantly reduce the effectiveness of bioventing for delivery of oxygen to contaminated soils. Information on the tanks indicates that they are 14 feet in diameter and extend to 15 feet bgs. Because the groundwater surface elevation varies between 7 and 13 feet bgs, no unsaturated soils are expected to be present beneath the tanks. A cross-section of the tanks reveals that very little space between the tanks

exists that is not saturated and that attempting to provide oxygen to soils between the tanks would be difficult. The actual volume of potentially contaminated unsaturated soils between the tanks is small when compared to other areas of the site. Attempting to provide oxygen to these soils would likely result in preferential vertical flow through the sandy fill around the tanks.

4.3 SYSTEM DESIGN

The proposed upgrade to the existing bioventing system at Building 2035 will incorporate the existing VW and two or more new VWs. Two new VMPs will also be constructed to monitor soil gas at the site. The additional VWs will be installed to ensure proper oxygen influence throughout the area of identified soil contamination. The new VWs will be 2 inches in diameter and will be screened with 0.040-inch slot from 5 to 15 feet bgs. Figure 4.1 shows the proposed locations of the existing and new VWs and VMPs. Trenchline configuration and other design details are included in the design package provided in Appendix A.

The VWs will be manifolded using 2-inch-diameter, schedule 80 PVC as the conduit for the injected air to flow from the blower to the proposed VWs. The piping will be connected to the new 2.0 HP regenerative blower and will be set at a depth of 18 inches beneath the ground surface. A separate (manual) flow control valve and flow measurement port will be included in the lines connecting each VW to allow adjustment of the air flow to each VW. The blower and valving will be housed in weatherproof enclosures for protection from the elements and for security purposes.

Based on experience at other bioventing sites, a maximum injection rate of 15 scfm at each VW should be sufficient to supply oxygen to the remaining contaminated soils and sustain *in situ* fuel biodegradation. The radius of oxygen influence around each VW was estimated to extend greater than 33 feet based on the data collected during the initial pilot testing. The VW locations were selected to make use of existing VMPs and to provide coverage of contaminated soils estimated in Figure 2.4. A spacing of approximately 80 feet between VWs is planned except near the area of greatest apparent vadose zone contamination (near the source area at Building 2034) where VWs are proposed at closer spacing (Figure 4.1).

Four additional soil boreholes will be advanced to further define the extent of soil contamination at this site. Figure 4.1 shows the location of these boreholes. If, based on field observations during installation of the soil boreholes, significant vadose zone contamination is encountered then VWs will be installed. If significant vadose zone contamination is not encountered in a soil borehole, either a monitoring well will be installed or the borehole will be abandoned.

4.4 PROJECT SCHEDULE

The following schedule for the bioventing system upgrade is contingent upon approval of the Work Permit Request.

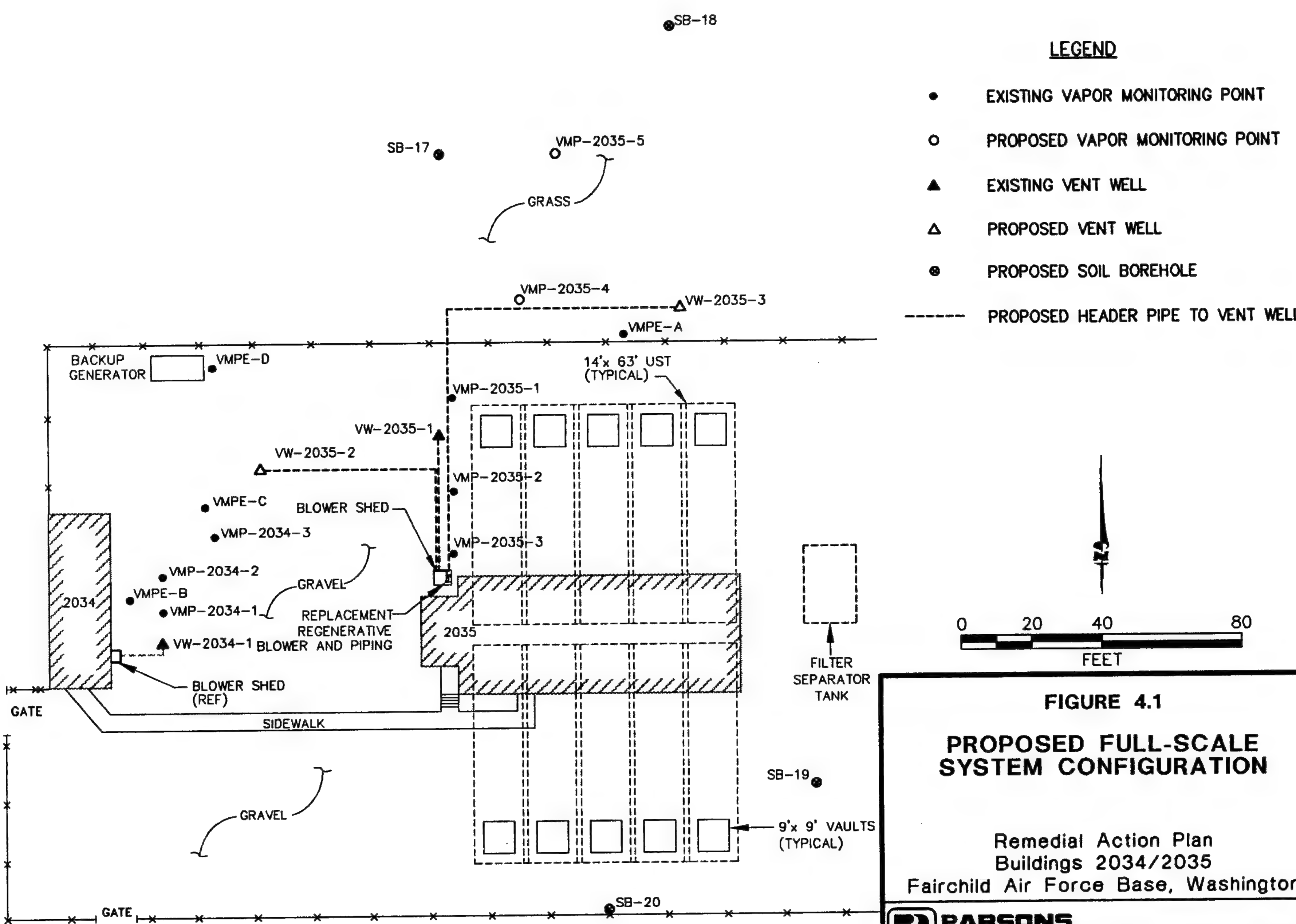


FIGURE 4.1

PROPOSED FULL-SCALE SYSTEM CONFIGURATION

Remedial Action Plan
Buildings 2034/2035
Fairchild Air Force Base, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

K:\AFCEE\726876\FAIRCHLD\96DN0045, 04/25/96 at 13:12

Event	Start Date	End Date	Duration (working days)
Submit Draft Remedial Action Plan and Design Package to AFCEE/ERT and Fairchild AFB	NA	12 February 1996	NA
Fairchild AFB Review Period	12 February 1996	29 February 1996	10 days
Respond to Comments on Draft	1 March 1996	7 March 1996	5 days
Submit Draft Final RAP to AFCEE/ERT, Fairchild AFB, USEPA[a/], and Washington Department of Ecology[a/]	NA	8 March 1996	NA
Draft Final Review Period	11 March 1996	12 April 1996	25 days
Respond to comments on Draft Final RAP	15 April 1996	29 April 1996	11 days
Final RAP and Design Package to AFCEE/ERT, Fairchild AFB, USEPA, and Washington Department of Ecology	NA	30 April 1996	NA
Submit Work Permit (digging permit) Request	NA	28 March 1996	NA
Construction of Expanded System/System Startup	13 May 1996	24 May 1996	10 days
Complete Construction Drawings/O&M Manual	27 May 1996	5 July 1996	30 days

[a/] Draft Final copies for USEPA and Washington Department of Ecology submitted by Fairchild AFB.

4.5 SYSTEM OPERATION, MAINTENANCE, AND MONITORING

Following system installation, Parsons ES engineers will perform system startup and optimization. An O&M plan and as-built system drawings will be prepared and submitted to AFCEE and Fairchild AFB. After the system has been optimized it will operate continuously until performance monitoring indicates that remedial objectives have been reached. At this time verification sampling will be performed, if required. The average of the biodegradation rates observed during the 17-month testing event of the pilot test (excluding the two highest rates) was 420 milligrams TPH per kilogram of soil per year. The highest TPH value detected at the site, that has not since been subject to bioventing treatment, is 1,700 mg/kg as TEPH at the 10 foot depths of SB-7 and SB-8. The Method A cleanup level for TPH in soils at industrial sites is 200 mg/kg (Washington State Department of Ecology, 1991). Based on these data the anticipated duration of system operation is approximately 4 years. This assumes that the bioventing is able to affect the targeted soils throughout the entire treatment period. Fluctuations in groundwater elevations may limit oxygen transport to target soils at certain times and affect the quantity of residual hydrocarbons in the soil.

4.5.1 System Operation

At startup of the full-scale system, it will be necessary to optimize the air injection rate and to ensure proper operation of the blower system. Flow rate optimization is accomplished by gradually increasing the flow rate to each VW until soil gas oxygen concentrations at all VMP depth intervals reach a minimum concentration of approximately 5 percent. Oxygen levels in excess of 5 percent at the outer VMPs may indicate that the volume of air passing through the soil exceeds the biological oxygen utilization. The blower will be checked to ensure that it is producing the required flow rate and pressure for air injection.

Following flow rate optimization, the system shall run continuously and will require minimal maintenance as described below. Parsons ES has been contracted by AFCEE to provide 1 year of system O&M support under Option 1 of the Extended Bioventing Project. O&M support will include performing any system repairs should the bioventing system fail to operate properly.

4.5.2 System Maintenance

System maintenance requirements for the proposed bioventing system are minimal because the regenerative blowers are virtually maintenance-free. The only recurring maintenance required is a monthly check of the air filter, which is generally replaced when the vacuum across the inlet filter reaches a reading 10 to 15 inches of water greater than the reading with a clean filter. The time period between filter changes is dependent on site conditions, and is typically every 3 to 6 months. The O&M manual will further detail maintenance requirements. Parsons ES is responsible for 1 year of maintenance support under Option 1 of the Extended Bioventing Project. Should the blower system give indications of an electrical or mechanical problem, such as a significant change in outlet pressure, abnormal noises from the blower, or system failure, during the first year of operation, Parsons ES will be responsible for repairing the system. Prior to mobilizing to the site, Parsons ES may request that a base electrician verify that adequate power is still being supplied to the blower motor. Once adequate power to the motor has been verified, Parsons ES will take the necessary actions to repair the blower system. Following the year of maintenance support by Parsons ES, Fairchild AFB will be responsible for system maintenance.

4.5.3 System Performance Monitoring

Routine monitoring of the bioventing system will include system checks of blower operation, including outlet pressures, inlet vacuum, and exhaust temperature every two weeks. These system checks will be performed by Fairchild AFB technicians.

To provide baseline data against which the progress of remediation can be evaluated, soil and soil gas samples will be collected during installation of the full-scale bioventing system. These data will be used along with the previous data collected throughout the pilot test project and in November 1995 to provide a basis for comparison in the future.

Soil samples will be collected from all boreholes advanced during drilling activities for installation of the full-scale bioventing system components. Samples will be collected at 2.5-foot intervals, and will be screened in the field for organic vapors using

a PID. Four soil samples will be sent to an analytical laboratory for analysis of BTEX by Method SW8020 and TEPH by Method SW8015 modified. These samples will be collected from the boreholes advanced for VMP-2035-4, VMP-2035-5, SB-19, and SB-20 (Figure 4.1) if field analysis indicates significant contamination is present at these locations.

Soil gas sampling will be conducted at all VMPs and VWs prior to system startup to establish baseline oxygen, carbon dioxide, and TVH levels using field instruments. In addition, soil gas samples from five locations will be forwarded to Air Toxics Ltd. of Folsom, California for analysis of TVH-jf and BTEX by Method TO-3. The locations of these samples will be determined based on the field screening results. The five intervals exhibiting the highest TVH concentrations based on field instruments will be sampled for laboratory analysis.

System performance monitoring by Parsons ES under Option 1 of the Extended Bioventing Project will include *in* situ respiration testing during a site visit after 1 year of full-scale system operation. Soil gas samples will also be collected from the same five VMPs sampled during full-scale system installation and reanalyzed for BTEX and TVH using Method TO-3. No soil sampling will be performed under Option 1 of the Extended Bioventing Project.

Prior to performing the 1-year respiration tests and soil gas sampling, the blowers will be turned off for 30 days to allow soil gas to equilibrate so that 1-year data can be compared to initial soil gas data. Air will be injected into VWs or VMPs for 20 hours, and then shut off. Oxygen uptake will be monitored in the VMPs for approximately 72 hours to measure the rate at which oxygen decreases in the soil gas. These data will then be used to estimate the current biodegradation rates and to evaluate the progress of contaminant removal and system effectiveness. As the fuel in the soil is depleted, the respiration activity of the indigenous microorganisms is reduced, and slower oxygen utilization rates result. The use of oxygen utilization and soil gas chemistry as indicators of remaining contaminant concentration decreases the likelihood of premature closure soil sampling events.

System monitoring and in situ respiration test data will be analyzed to determine the progress of soil remediation. Estimates of contaminant reduction and time remaining to complete soil remediation will be based on the data collected during the respiration tests (oxygen utilization rates), quantitative estimates of the long-term biodegradation rates, and decreases in soil gas concentrations. If soil gas data indicate that the soils have been sufficiently remediated, closure sampling may be recommended.

Because it has been estimated that remediation to the TPH cleanup level of 200 mg/kg will take approximately 4 years, Fairchild AFB will be responsible for monitoring the performance of remediation after the initial year of full-scale operations when Parsons ES's obligations will be completed. It is recommended that annual respiration testing and soil gas sampling be performed to evaluate the progress of remediation. The annual costs to performed these activities, assuming that they are performed by a contractor, are provided in Table 4.1. In addition to these activities, monitoring the system pressure, vacuum, and temperature should be performed every 2 weeks.

TABLE 4.1
ESTIMATE OF ANNUAL PERFORMANCE MONITORING COSTS
BUILDINGS 2034/2035
REMEDIAL ACTION PLAN
FAIRCHILD AFB, WASHINGTON

LABOR COSTS

	Labor Hours						
Task	Senior $115.00	Midlevel $80.00	Junior $60.00	Technician $45.00	Support $40.00	Total Hours	Total Costs
Project Management	6	6	6	6	8	32	$2,120.00
Field Testing/Sampling	2	8	60	20	15	105	$5,970.00
Letter Report Preparation	4	12	8	8	10	42	$2,660.00
Total Labor Hours	12	26	74	34	33	179	
Total Labor Costs	$1,380.00	$2,080.00	$4,440.00	$1,530.00	$1,320.00		$10,750.00

OTHER DIRECT COSTS (ODCs)

Item	Unit	Unit Cost	Quantity	Total
Per Diem	Day	$100.00	8	$800.00
Airfare	Each	$1,213.00	2	$2,426.00
Truck Rental	Week	$250.00	1	$250.00
O&M Supplies	Lump Sum	$250.00	1	$200.00
Computer Charges	Lump Sum	$150.00	1	$150.00
Reproduction	Page	$0.04	200	$8.00
Shipping	Lump Sum	$150.00	1	$100.00
Telephone	Lump Sum	$100.00	1	$50.00
Facsimile	Page	$0.70	20	$10.00
Analytical Services (soil gas)				
TPH and BTEX (TO-3)	Each	$120.00	4	$480.00
Shipping	Each	$50.00	1	$50.00
		Total ODCs		$4,524.00

TOTAL ANNUAL COSTS = $15,274.00

SECTION 5

HANDLING OF INVESTIGATION-DERIVED WASTES

All soil cuttings will be containerized in a roll-off container at the site. Soil cuttings will be accumulated in the roll-off container throughout the drilling program. The roll-off container will be covered with tarps when not in use to eliminate accumulation of precipitation and windblown dust. Following completion of drilling activities, the roll-off container will be removed from the site by a waste handling subcontractor. Arrangements are currently being made to have the soil cuttings pre-approved for acceptance by the Base's waste-handling subcontractor based on previous analytical data and knowledge of the source of contamination (jet fuel tanks). It is anticipated that 1.4 cubic yards (38 cubic feet) of soil cuttings will be generated during installation of the full-scale bioventing system.

Decontamination of augers, sampling equipment, and all other items requiring decontamination will be performed at a temporary decontamination area set up at the site. Decontamination water will be placed in 55-gallon drums and stored at the site within the unused portion of the roll-off container. After completion of drilling activities, the waste-handling subcontractor will test for the presence of chlorinated compounds with a field instrument, and immediately remove the decontamination water from the site if none are found.

SECTION 6

BASE SUPPORT REQUIREMENTS

The following support from Fairchild AFB is needed prior to the arrival of the drillers and the Parsons ES team:

- Assistance in obtaining a Base digging permit.
- Obtaining all necessary regulatory permits for the VWs and VMPs, and monitoring wells.
- Assistance in obtaining any air permits required.
- Provide a copy of any Base soils management plan (SMP) and/or sampling and analytical procedures (SAP) plan.
- Provide any paperwork required to obtain gate passes and security badges for drilling personnel and two Parsons ES employees. If required by the Base, vehicle passes will be needed for two Parsons ES trucks, one drill rig, and two drilling support trucks. These passes must be valid for the expected duration of drilling operations (about 1 week) and the full-scale system installation and startup (about 3 weeks).
- A potable water supply for well construction and decontamination activities.

During full-scale bioventing, Base personnel will be required to check the blower systems once every two weeks to ensure that they are operating properly, record air injection pressures and temperatures, and replace air filters, as needed. Parsons ES will provide a maintenance procedures manual and a brief training session.

1. If a blower stops working, notify Mr. Brian Blicker of Parsons ES at (406) 586-7899, Mr. John Ratz of Parsons ES - Denver at (303) 831-8100, or Capt Ed Marchand of AFCEE at (210) 536-4364.

2. Arrange site access for a Parsons ES technician to conduct respiration testing and soil gas sampling approximately 1 year after full-scale system installation and start up.

SECTION 7

POINTS OF CONTACT

Mr. Bruce Oshita
92 CES/CEV
100 W. Ent St., Suite 155
Fairchild AFB, WA 99011-9404
(509) 247-5170
Fax (509) 247-2878

Captain Kristin Myers
92 CES/CEV
100 W. Ent St., Suite 155
Fairchild AFB, WA 99011-9404
(509)247-5170
(509)247-2878

Mr. Patrick Haas
AFCEE/ERT
8001 Arnold Drive
Brooks AFB, TX 78235
(210) 536-4314
Fax: (210) 536-4330

Captain Edward Marchand
AFCEE/ERT
8001 Arnold Drive
Brooks AFB, TX 78235
(210) 536-4364
Fax: (210) 536-4330

Mr. John Ratz, Project Manager
Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, CO 80290
(303) 831-8100
Fax: (303) 831-8208

Mr. Brian Blicker, Site Manager
Parsons Engineering Science, Inc.
214 N. Plum Ave., #A
Bozeman, MT 59715
(406) 586-7899
Fax: (406) 586-7899

SECTION 8

REFERENCES

Halliburton NUS. 1993. *Feasibility Study Report Priority One Operable Units (Final).* February.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* January.

Engineering-Science, Inc. 1994. *Part I, Bioventing Work Plan and Part II, Draft Bioventing Pilot Test Interim Results Report for PS-2, PS-1A, PS-1B, Building 2034, Building 2035. Fairchild Air Force Base, Washington.* June.

Rittenhouse-Zeman & Associates (RZA). 1988. *Underground Storage Tank Study Phase I.* January.

US Environmental Protection Agency (USEPA). 1986. *Measurement of Gaseous Emission Rates from Land Surface Using an Emission Isolation Flux Chamber: User's Guide*, EPA/600/8-86/008, February.

Washington State Department of Ecology. 1991. *The Model Toxics Control Air Cleanup Regulation.* February.

APPENDIX A

DESIGN PACKAGE

CONSTRUCTION DRAWINGS FOR

EXPANDED BIOVENTING SYSTEM BUILDINGS 2034/2035 FAIRCHILD AIR FORCE BASE

PREPARED FOR

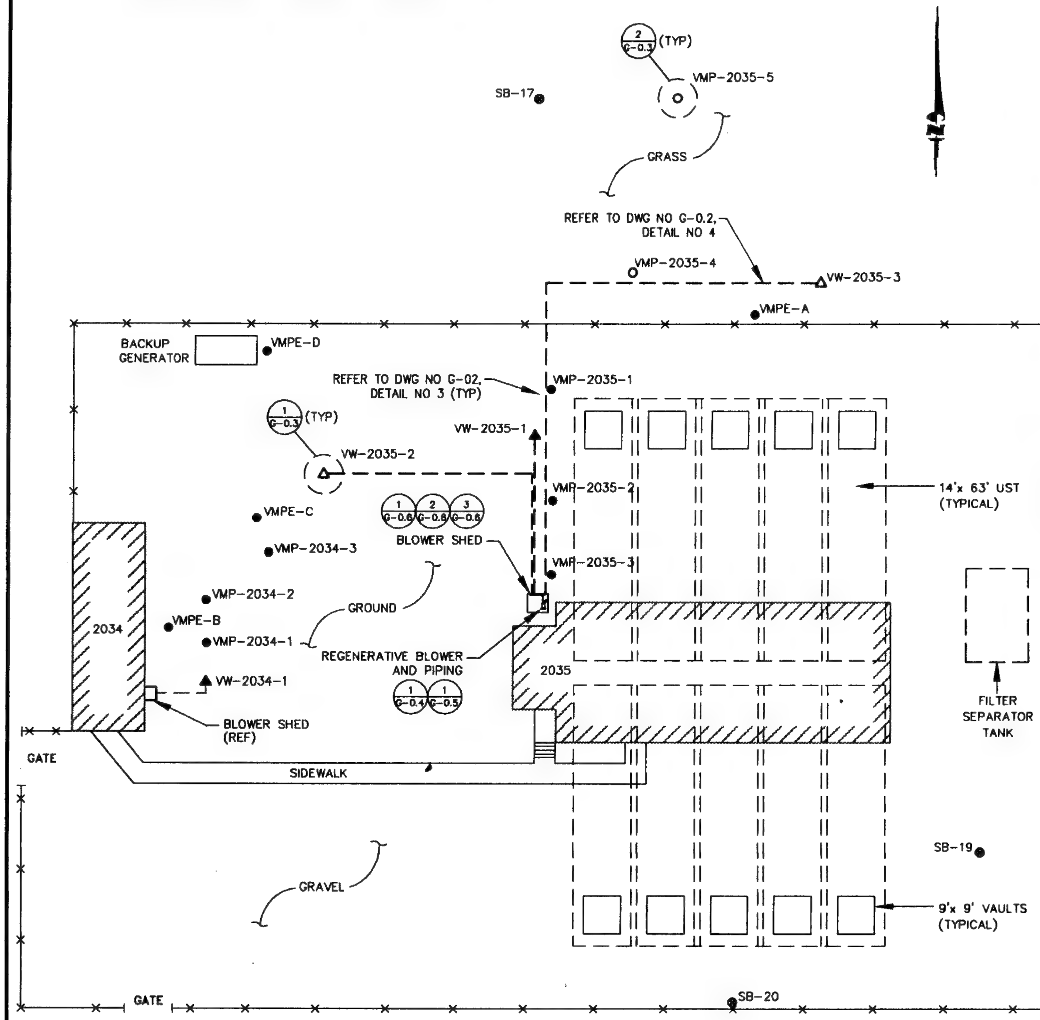
AFCEE

APRIL 1996

DRAWING INDEX

DRAWING NO	DRAWING NAME
G-0.1	TITLE SHEET AND SITE LAYOUT
G-0.2	LEGEND AND STANDARD TRENCH DETAIL
G-0.3	VENT WELL AND MONITORING POINT STANDARD DETAILS
G-0.4	BLOWER P & ID
G-0.5	BLOWER PIPING LAYOUT DETAIL
G-0.6	BLOWER SHED FIELD INSTALLATION DETAIL AND BLOWER SHED CONSTRUCTION DETAIL

NOTE:
IF SIGNIFICANT CONTAMINATION OF THE UNSATURATED ZONE IS EVIDENT UPON DRILLING OF SB-17, SB-18, SB-19, OR SB-20, THESE BOREHOLES MAY BE COMPLETED AS VENT WELLS. OTHERWISE THEY MAY BE COMPLETED AS MONITORING WELLS.



SITE LAYOUT

SCALE: 1"=30'

Job No. 726876.40142				
Designed BRB				
Drawn MW				
Checked				
Reviewed				
Approved	B	4/26/96	100% DESIGN	
Reg No.	A	1/17/96	65% DESIGN	
Date	Rev	Date	Description	By

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)

EXPANDED BIOVENTING SYSTEM BUILDINGS 2034/2035 FAIRCHILD AIR FORCE BASE

TITLE SHEET AND SITE LAYOUT

DRAWING NO G-0.1 REV B

K:\AFCEE\726876\FAIRCHLD\96DN0072, 04/26/96 at 11:50

ABBREVIATIONS

AIJ	AIR INJECTION
APPROX	APPROXIMATE
ASTM	AMERICAN SOCIETY OF TESTING AND MATERIALS
&	AND
@	AT
CBM	CENTER BACK MOUNT
CLR	CLEAR
DIA	DIAMETER
EB	EXPLORATORY BORING
ECC	ECCENTRIC
EW	EACH WAY
FOT	FLAT ON TOP
FPT	FEMALE PIPE THREAD
FT	FOOT
GALV	GALVANIZED STEEL
ie	FOR EXAMPLE
LM	LOWER MOUNT
MAX	MAXIMUM
MIN	MINIMUM
MP	MONITORING POINT
MPT	MALE PIPE THREAD
NO, #	NUMBER
NPT	NATIONAL PIPE THREAD
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
PVC	POLYVINYL CHLORIDE
PW	PROPOSED WELL
RED	REDUCER
REF	REFERENCE
SCH	SCHEDULE
S	SOCKET
SPVC	SLOTTED POLYVINYL CHLORIDE
ST STL	STAINLESS STEEL
TYP	TYPICAL
UST	UNDERGROUND STORAGE TANK
VW	VENT WELL
W/	WITH
WN	WELD NECK
WWF	WELDED WIRE FABRIC

SYMBOLS

SB-20 ⊗	PROPOSED SOIL BOREHOLE
VMP-2034-1 ●	EXISTING BIOVENTING MONITORING POINT
VMP-2035-4 ○	PROPOSED BIOVENTING MONITORING POINT
VW-2035-1 ▲	EXISTING VENT WELL
VW-2035-2 △	PROPOSED VENT WELL
— — —	PROPOSED HEADER PIPE TO VENT WELL
— — —	EXISTING HEADER PIPE TO VENT WELL
—x—x—	FENCE

SECTION DESIGNATION — SECTION NAME
(A / X) **SECTION CUT**
SCALE: NTS
DRAWING OF ORIGIN — SCALE

DETAIL NO — DETAIL NAME
(1 / X) **DETAIL DESCRIPTION**
SCALE: NTS
DRAWING OF ORIGIN — SCALE

MATERIAL LEGEND

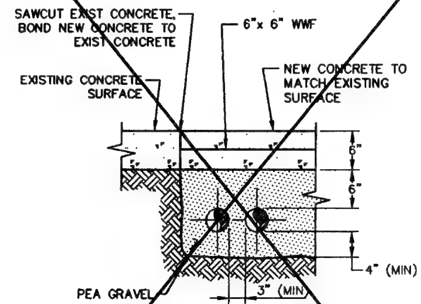
- ASPHALT
- BENTONITE
- BENTONITE/CEMENT GROUT
- BENTONITE PELLETS
- BUILDING (EXISTING)
- COMPACTED BACKFILL
- COMPACTED BASE STONE
- CONCRETE
- PEA GRAVEL
- SAND
- UNDISTURBED SOIL

PIPE MATERIAL

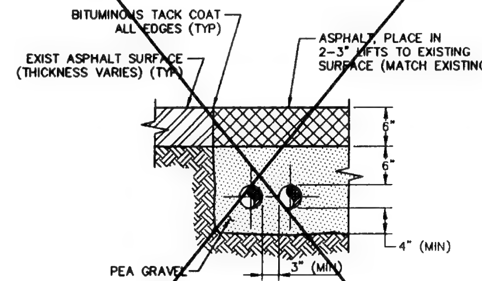
CS	CARBON STEEL
GALV	GALVANIZED STEEL
PVC	POLYVINYL CHLORIDE
SPVC	SCREENED POLYVINYL CHLORIDE

PIPE SERVICE

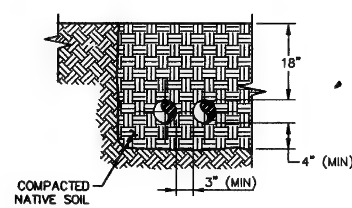
AIJ	AIR INJECTION
BIV	BIOVENTING
DR	DRAIN



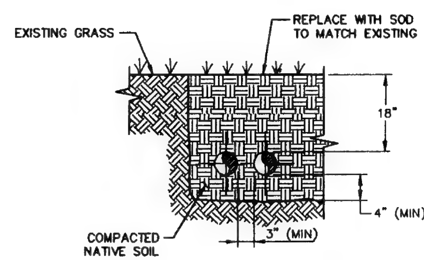
(1 / –) CONCRETE REPLACEMENT DETAIL
SCALE: NTS



(2 / –) ASPHALT REPLACEMENT DETAIL
SCALE: NTS



(3 / –) SOIL COVER REPLACEMENT DETAIL
SCALE: NTS



(4 / –) GRASS COVER REPLACEMENT DETAIL
SCALE: NTS

Rev	Date	Description	By
B	4/24/96	100% DESIGN	
A	1/17/96	65% DESIGN	

Job No. 726876.40142
Designed BRB
Drawn MW
Checked
Reviewed
Approved
Reg No
Date

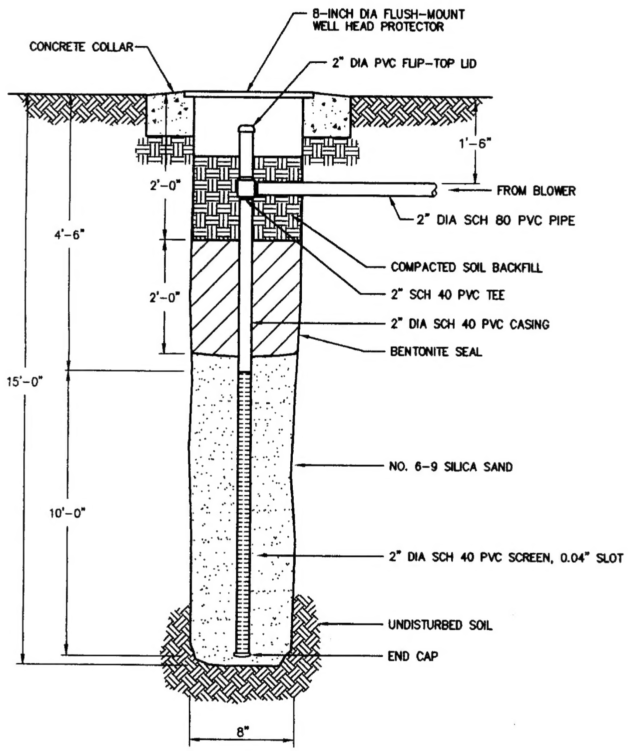
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)
EXPANDED BIOVENTING SYSTEM
BUILDINGS 2034/2035
FAIRCHILD AIR FORCE BASE

LEGEND AND STANDARD TRENCH DETAILS

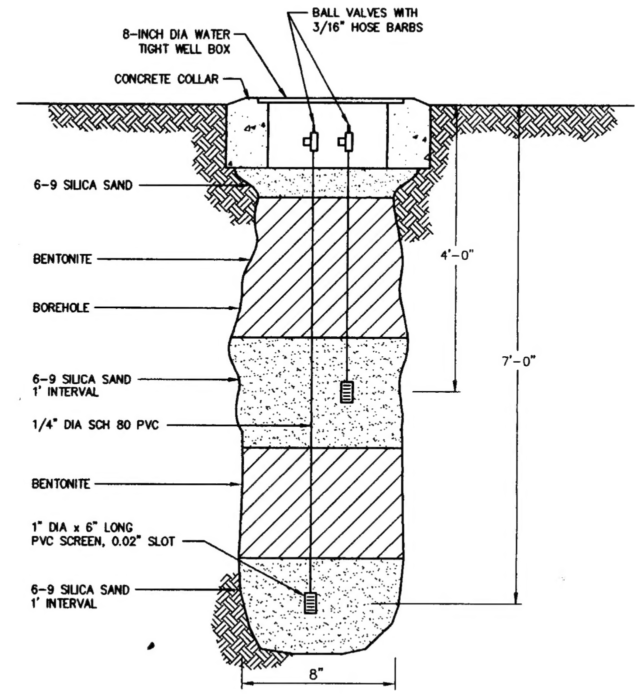
DRAWING NO G-0.2 REV B

K:\AFCEE\...



1 VENT WELL (VW) DETAIL

SCALE: NTS



2 MONITORING POINT (MP) DETAIL

SCALE: NTS

NOTE:
ACTUAL DEPTHS OF SCREENED INTERVALS WILL BE BASED ON FIELD OBSERVATIONS.

Job No. 726876.40142				
Designed BRB				
Drawn MW				
Checked				
Reviewed				
Approved	B	4/24/95	100% DESIGN	
Reg No	A	1/17/95	65% DESIGN	
Date	Rev	Date	Description	By

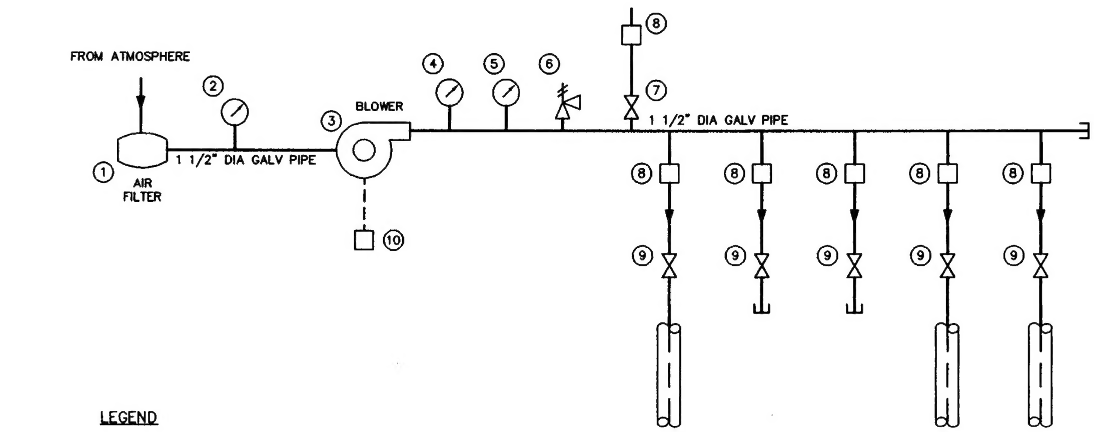
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)
EXPANDED BIOVENTING SYSTEM
BUILDINGS 2034/2035
FAIRCHILD AIR FORCE BASE

VENT WELL AND MONITORING POINT STANDARD DETAILS

DRAWING NO G-0.3 REV B

K:\AFCEE\726876\FAIRCHILD\... 04/23/96 at 15:17



LEGEND

1. INLET AIR FILTER – SOLBERG F-30P-150, REPLACEMENT ELEMENT 30P
2. VACUUM GAUGE –GAST® AJ497, 2 1/2" DIA, 0–60" H_2O, 1/4" NPT, LM
3. BLOWER – GAST® 2.0HP R5125Q-50, 92 CFM AT 30" H_2O PRESSURE
4. TEMPERATURE GAUGE – ASHCROFT, 0–250°F, 1/2" NPT, CBM (Part No. 2A606 FROM GRAINGER)
5. PRESSURE GAUGE – WIKA 611.10, 2 1/2" DIA., 0–100" H_2O, 1/4" NPT, LM (Part No. 9851810)
6. AUTOMATIC PRESSURE RELIEF VALVE – GAST® AG258, SET TO RELEASE AT 40" H_2O PRESSURE
7. MANUAL PRESSURE RELIEF (BLEED) VALVE – 1 1/2" GATE
8. FLOW MEASURING PORT FITTED WITH PLUG (1/4" x 1/8" NPT BRASS REDUCING BUSHING, 1/8" NPT BRASS PLUG)
9. FLOW CONTROL VALVE – 1 1/2" GATE
10. STARTER

1 BLOWER PIPING AND INSTRUMENTATION DIAGRAM

SCALE: NTS

Rev	Date	Description	By
B	4/26/96	100% DESIGN	
A	1/17/96	65% DESIGN	

Job No. 726876.40142
Designed BRB
Drawn MW
Checked
Reviewed
Approved
Reg No
Date

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

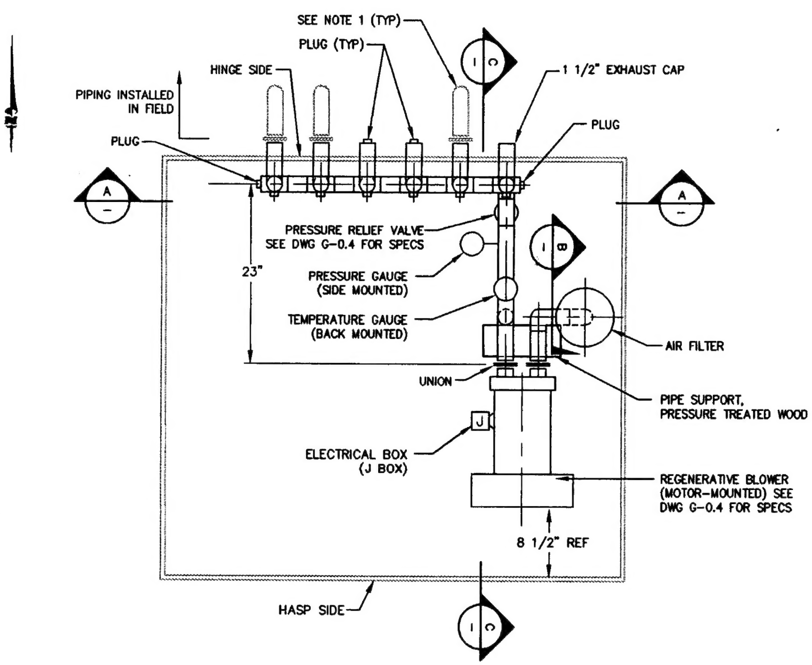
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)

EXPANDED BIOVENTING SYSTEM
BUILDINGS 2034/2035
FAIRCHILD AIR FORCE BASE

BLOWER P & ID

DRAWING NO G-0.4 REV B

K:\AFCEE\726876\FAIRCHLD\96DN0075 04/ /9 ...

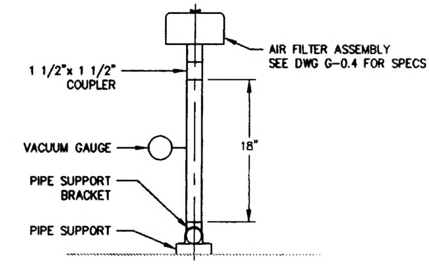


1 BLOWER PIPING LAYOUT PLAN DETAIL

3/4" = 1'-0"

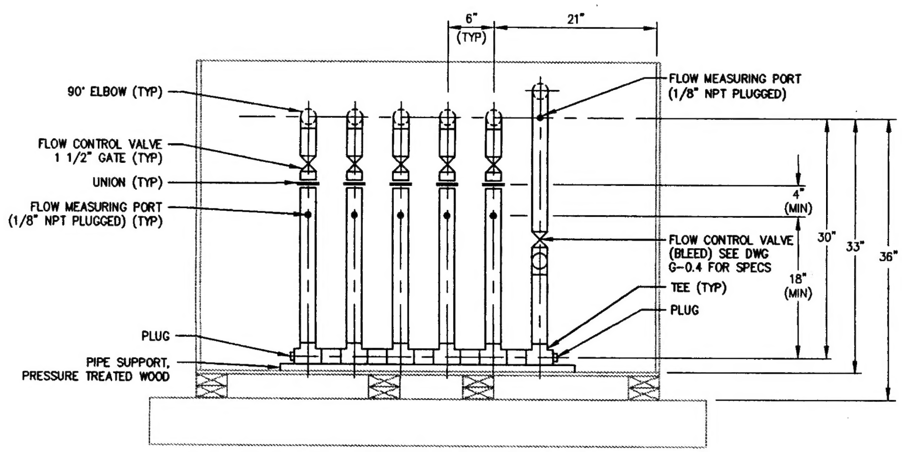
NOTES:

1. SHOP CORE HOLES TO PIPING DIMENSIONS
2. ALL PIPING 1 1/2" DIA. GALVANIZED STEEL, UNLESS OTHERWISE NOTED
3. SEE DRAWING G-0.6 FOR BLOWER BUILDING DETAILS



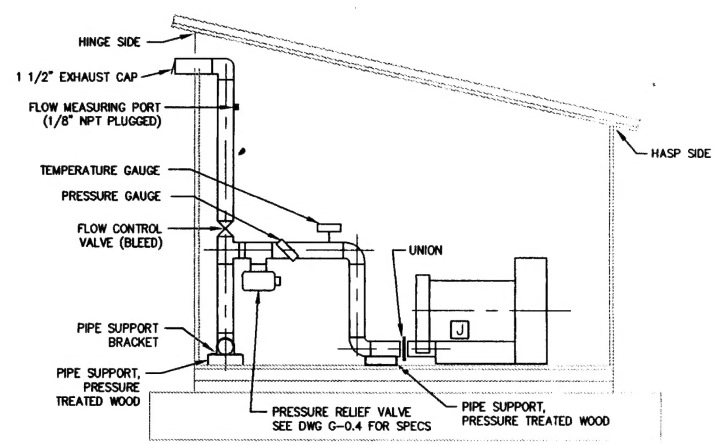
B BLOWER INLET PIPING SECTION

3/4" = 1'-0"



A MANIFOLD DETAIL SECTION

3/4" = 1'-0"



C BLOWER OUTLET PIPING SECTION

3/4" = 1'-0"

Job No. 726876.40142					
Designed BRB					
Drawn MW					
Checked					
Reviewed					
Approved		B	4/26/96	100% DESIGN	
Reg No		A	1/17/96	65% DESIGN	
Date		Rev	Date	Description	By

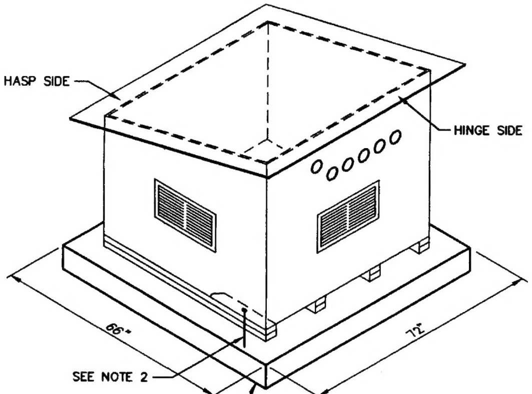
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)

EXPANDED BIOVENTING SYSTEM
BUILDINGS 2034/2035
FAIRCHILD AIR FORCE BASE

BLOWER PIPING LAYOUT DETAIL

DRAWING NO G-0.5 REV B

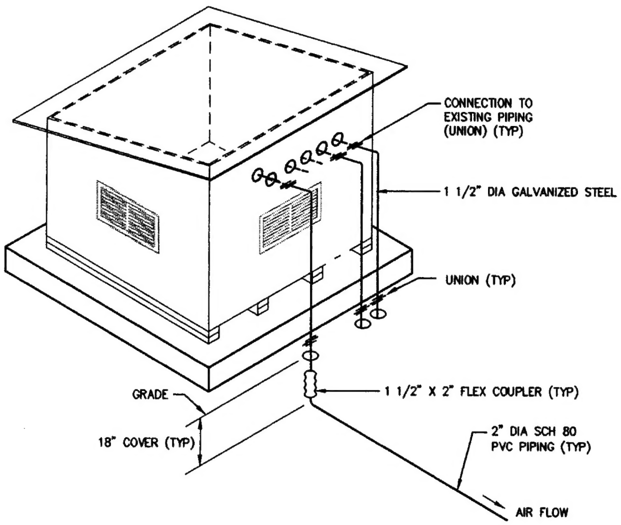


NOTES:

1. FIELD INSTALL BUILDING CENTRAL ON CONCRETE SLAB WITH ORIENTATION AS SHOWN
2. FIELD SECURE BLOWER SHED TO CONCRETE SLAB AT LOCATIONS BY THRU BOLTING. USE 3/8"x 6" LONG ST STL WEDGE ANCHOR BOLTS

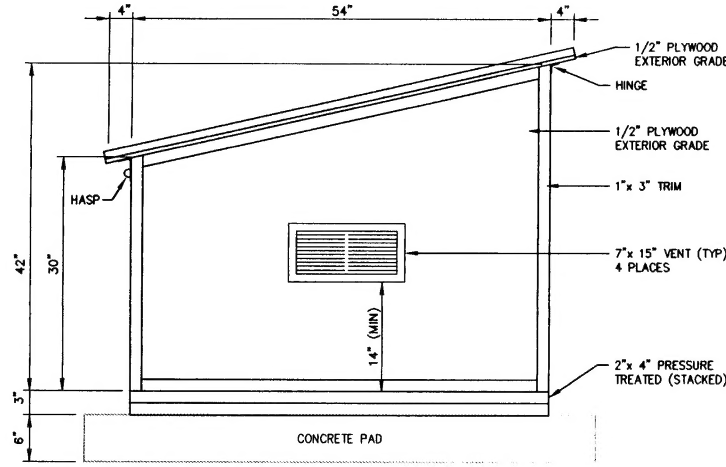
(1/–) BLOWER SHED FIELD INSTALLATION DETAIL

NOT TO SCALE

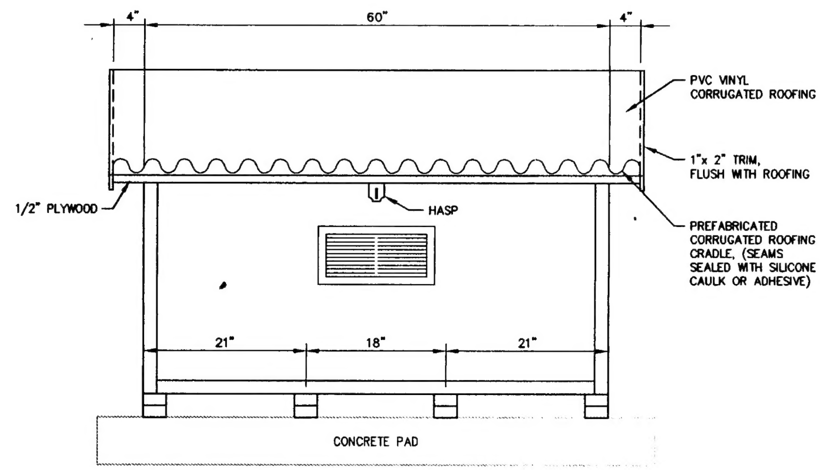


(2/–) TYPICAL MANIFOLD DISCHARGE PIPING LAYOUT

NOT TO SCALE



SIDE ELEVATION



FRONT ELEVATION

NOTES:

1. 2"x 2" FRAME CONSTRUCTION
2. FLOOR CONSTRUCTED OF 3/4" EXTERIOR GRADE PLYWOOD
3. ROOF CONSTRUCTED OF 1/2" EXTERIOR GRADE PLYWOOD COVERED WITH PVC VINYL CORRUGATED ROOFING

(3/–) BLOWER SHED CONSTRUCTION DETAIL

3/4" = 1'-0"

Job No. 726876.40142				
Designed BRB				
Drawn MW				
Checked				
Reviewed				
Approved	B	4/28/96	100% DESIGN	
Reg No	A	1/17/96	65% DESIGN	
Date	Rev	Date	Description	By

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)
EXTENDED BIOVENTING TREATABILITY TEST
BUILDINGS 2034/2035
FAIRCHILD AIR FORCE BASE

BLOWER SHED FIELD INSTALLATION DETAIL AND BLOWER SHED CONSTRUCTION DETAILS

DRAWING NO G-0.6 | REV B